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TRANSPORTATION RESEARCH COMMAND
FORT EUSTIS, VIRGINIA

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LIGHTER, BEACH DISCHARGE, DECK CARGO, DIESEL, STEEL, 300-FOOT, DESIGN 5002

Task 9R57-02-018-01

(Formerly Project 9-57-03-000, Task 109M)

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ENGINEERING REPORT

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U. S. ARMY TRANSPORTATION RESEARCH COMMAND

Fort Eustis, Virginia

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SUMMARY

This engineering report covers the design, construction, and testing of a pilot model of a beach discharge lighter. The item was developed to fulfill a requirement for a shallow-draft, self-propelled lighter to transport large quantities of mobile and/or outsized equipment to a beach for resupply in ship-to-shore operations. The lighter was to have a capacity far surpassing that of existing available craft, to be capable of loading and discharging on a beach by means of a ramp, to be highly maneuverable, and to be capable of rapid retraction from a beach. The ultimate objective of the project was to type classify the item for the Transportation Corps Marine Fleet.

The project included the testing of a 25-foot model to determine the feasibility of a vessel of the type proposed. It also included the development of four concepts of vessel design and propulsion, the evaluation of the concepts, and a self-propelled test-model test of the selected design concept. The problem of integrating the lighter with roll-on/roll-off ocean vessels was studied during the model testing by estimating the motion of the vessels and the forces involved. Mooring arrangements and devices were developed.

The testing started with the acceptance trials at San Diego, California. The vessel's behavior at sea and operational characteristics in congested harbors were determined on its voyage from San Diego to San Francisco, California, to Fort Eustis, Virginia, via the Panama Canal. Further confirmation was obtained from operations in the Hampton Roads and Chesapeake Bay area, and from a voyage to France. Beaching tests were conducted at Little Creek, Virginia, and the off-shore operation was conducted at Fort Story, Virginia. Marriage tests with the "USNS Comet" were undertaken in the Chesapeake Bay and off the Virginia Capes. Discharge of the Comet was accomplished in a NODEX operation off the coast of France. Standardization tests with both the sinusoidal and Rotor "A" linkage were conducted by personnel of the David Taylor Model Basin on the course at Kent Island, Maryland. Model Basin personnel also conducted a vibration test in Panama and made a model flow study in their circulating water channel.

The vessel was found to be very maneuverable, and its behavior at sea was found to be good. Its bow has a tendency to "fall off", and large thrust angles are required to maintain course. The vessel can be beached and readily retracted without the use of a stern anchor. Marriage with a roll-on/roll-off vessel and transfer of vehicles was proven feasible; however, the operation is limited to relatively smooth water. Because of the forward landing draft, a dry ramp is obtainable only on steep beaches.

The vibration in the shaft alley and propeller room bulkheads was found to be propeller excited. Vibration amplitudes were found to increase with pitch settings and rpm, and were larger with the sinusoidal propeller linkage than with the Rotor "A" type. The sinusoidal linkage overloaded the engines at full pitch. With the Rotor "A" linkage, full power of the engines was not absorbed by the propellers, and an increase in speed of approximately 1/2 knot was obtained. Difficulty in control was encountered with the Rotor "A" linkage. Also, a control stick oscillation, occurring once per revolution, was prevalent with the Rotor "A" linkage. The source of this oscillation could not be determined, and the Rotor "A" linkage was replaced with the original sinusoidal linkage.

It was concluded that the vessel fulfills the major requirements of the military characteristics and that it should be type classified as Standard A.

CONCLUSIONS

It is concluded that:

1. The Lighter, Beach Discharge, Deck Cargo, Diesel, Steel, 300-Foot, Design 5002 (BDL-1X), meets the required military characteristics with the following exceptions:

    a. The lighter has a cargo capacity of 600 long tons with a landing draft of 4 feet forward and 10 feet aft, in lieu of a cargo capacity of 600 long tons for any landing condition without draft limitation.

    b. The lighter has a cruising speed of 8-1/2 knots and a trial speed of 9-1/2 knots with 600 long tons of cargo, in lieu of 14 knots for 600 long tons of cargo.

    c. The lighter was not tested under the temperature extremes specified. Living conditions, however, were found to be uncomfortable in high temperatures encountered in both the temperate and tropical zones.

2. The lighter is highly maneuverable and capable of operation in congested areas without the aid of other vessels.

3. The lighter is capable of integration with ocean-type roll-on/roll-off vessels when weather conditions are such that the relative vertical motion between the two vessels is less than 4 feet.

4. When beaching under the minimum draft conditions, a dry ramp cannot be obtained, and vehicles must ford 4 feet of water.

RECOMMENDATIONS

These recommendations are made as suggestions for the development of an improved vessel, and many will be neither applicable nor feasible for the existing vessel. In view of this, it is recommended that:

1. The lighter be designed to have a landing draft, with 600 long tons of cargo, of 4 feet forward and 10 feet aft, and a beach gradient of 1 to 50.

2. The lighter be designed for a speed, at landing draft, of 12 knots at 85 percent of full power.

3. Ventilation in the living spaces be improved.

4. The steering ratio be increased to approximately 10 to 1 in order to provide better control at small thrust angles.

5. The after steering station be deleted and a portable conning station be substituted.

6. An after steering and control station be provided in the propeller room.

7. An emergency manual control for both pitch and thrust angles be provided in the propeller room.

8. A bow thruster be installed in the bow to prevent the bow from "falling off" and to afford better control when docking and operating in congested areas.

9. A steadying skeg be installed to improve course-keeping qualities.

10. The bulwarks be deleted and the hull depth be increased 1 foot.

11. The bulkheads of the shaft alleys and propeller room be made heavier and stiffened such that their natural frequency does not correspond to the propeller blade frequencies.

12. The propeller foundations be extended beyond the after end of the skeg, and the discontinuities in the hull structure be minimized to the greatest extent practicable.

13. The ballast system be capable of trimming the vessel at the rate of 1-1/2 inches per minute when ballasting from the sea with the vessel loaded with 600 tons of cargo at landing draft.

14. The main deck manhole covers and bolts be recessed such that they will not be damaged by tracked vehicles.

15. The thickness of the end of the ramp be reduced so as to offer less of an obstacle to wheeled vehicles.

16. The fenders be extended forward in way of the forecastle flare to prevent damage when docking.

17. The after corners of the forecastle deck be rounded at the sheer to prevent damage when coming alongside other vessels.

18. An indicator to show the ram position be provided, if the retractor ram is to be used.

19. The vessel be equipped with heavy anchors of the stockless type.

20. Provisions be made for securing the warping lines further forward so as to permit marriage of the beach discharge lighter and the roll-on/roll-off vessel when the relative vertical motion is 6 feet.

21. The vertical clearance in the ramp tunnel be increased to 15 feet 6 inches.

22. Internal draft gages be provided in order that draft and trim can be readily determined when ballasting.

23. Maintenance facilities be provided in consonance with the maintenance concept.

24. A stowage room be provided for spare parts so that it will not be necessary to stow them in metal boxes.

25. A suitable access hatch be provided for shipping and unshipping machinery.

26. Nonstructural tanks, fitted with heaters, be provided for propeller lubricating and hydraulic oil.

27. The chocks and bitts on the forecastle be arranged such that all head mooring lines can be handled from one level.

28. The instruments in the pilot house be grouped and located such that they can be readily read by all personnel on watch, and lighted such that they can be seen at night without affecting visibility from the pilot house.

29. The pitch controls for both of the propellers be consolidated in a single unit, and a control station be provided on each side of the pilot house.

30. Inclined ladders be provided from the main deck to the forecastle deck.

31. Combined helm-angle and thrust-angle indicators be provided in the pilot house for both of the propellers.

32. Stowage for spare propeller blades be provided in the shaft alleys, and a suitable lifting gear and monorail system be installed for the movement of blades from the stowage racks and installation in the propellers.

33. The design head for all ballast and fuel tanks be 5 feet above the main deck.

34. The primary reduction gears be eliminated, and the full reduction from engine rpm to propeller rpm be made in the propellers.

35. The hydraulic couplings for the main engines be eliminated.

36. General alarm bells, which would be audible above the machine noise, be installed in the machinery spaces.

37. Speakers for the general announcing system located in the machinery spaces have sufficient volume to be audible above the machinery noise.

38. The source of power for preheating the emergency generator engine be obtained from the emergency generator storage batteries.

39. Condensate and fresh water lines be located outside of the ballast tanks.

40. All surfaces of the weather decks (shell, etc.) which are exposed to living spaces be insulated, including the webs and flanges of beams, girders, frames, and stiffeners.

41. Side lights be located at the bridge deck level and be screened so that they cannot be seen across the bow.

42. The vents on the ballast tanks be sized such that the static and dynamic heads during overflow cannot exceed the designed head of the tanks.

43. A positive lock be provided for securing the retractor ram in the "up" position.

44. The heating system be designed to fulfill the requirements of the lower temperature established by the military characteristics.

45. Independent overboard discharges be provided for the distiller and refrigeration condensers.

46. All lubrication systems be fitted with low-pressure alarms.

47. A fuel oil transfer system be provided.

48. Consideration be given to the installation of the minimum and most economical gyro system required for the primary mission of the vessel.

49. Ramp chains be secured to the ramp such that there is no projection below the bottom of the ramp.

50. A ramp gasket be designed such that the entire gasket is in the same plane.

51. A method for lubricating the ramp hinges be provided.

52. Bitts be provided in the ramp tunnel for mooring small craft to the ramp.

53. Insect screens be provided for all weather openings.

54. All extensions of the sides above the main deck have tumble home to prevent damage when alongside other vessels.

55. The outboard sea chest be eliminated and a single sea chest of the free-surface vented type be provided.

56. Consideration be given to the utilization and adaptability of the vessel to other missions during peacetime.

57. The area provided for truck drivers be fitted with portable berthing for peacetime use.

BACKGROUND

The present and future support of military operations requires the use of large quantities and varieties of vehicular and mobile equipment. For this reason, and because of the increased capability of the roll-on/roll-off ocean transport, a more expeditious type of ship-to-shore transportation than is found in the existing lighterage available to the U. S. Army Transportation Corps is necessary.

To fulfill this requirement, it was proposed to develop, construct, and test a prototype vessel. The design would permit the vessel to have the following characteristics: large cargo capacity, high speed, facilities for rapid loading and unloading of all types of mobile equipment, ease of maneuverability, capability for self-delivery to destination, and ability to operate in shallow water. The proposed operational use of such a vessel was to incorporate it into certain heavy boat companies in lieu of the LCU-6 as a lighter for heavy lifts and vehicles.

The U. S. Army Transportation Board recommended that the U. S. Army Transportation Research Command (USATRECOM) be directed to initiate a project for the design and construction of a prototype vessel in accordance with the proposed physical and military characteristics given in Appendix I. It was also recommended that the design study include a thorough investigation of the power steering mechanism, and that consideration be given to the use of cycloidal propulsion. At the 78th meeting of the Transportation Corps Technical Committee (TCTC), a development project was initiated and the military characteristics were established. The characteristics for the vessel and the authority for Project 9R57-02-018-01 are given in Appendix II.

In order to ascertain the practicability of a vessel of the type required, extensive model testing was carried out by USATRECOM on a 25-foot model (Figure 1). The Stevens Institute of Technology, Hoboken, New Jersey, under the auspices of USATRECOM, conducted tests on a smaller model in their Experimental Towing Tank. The model tests made it evident that a suitable vessel was feasible.

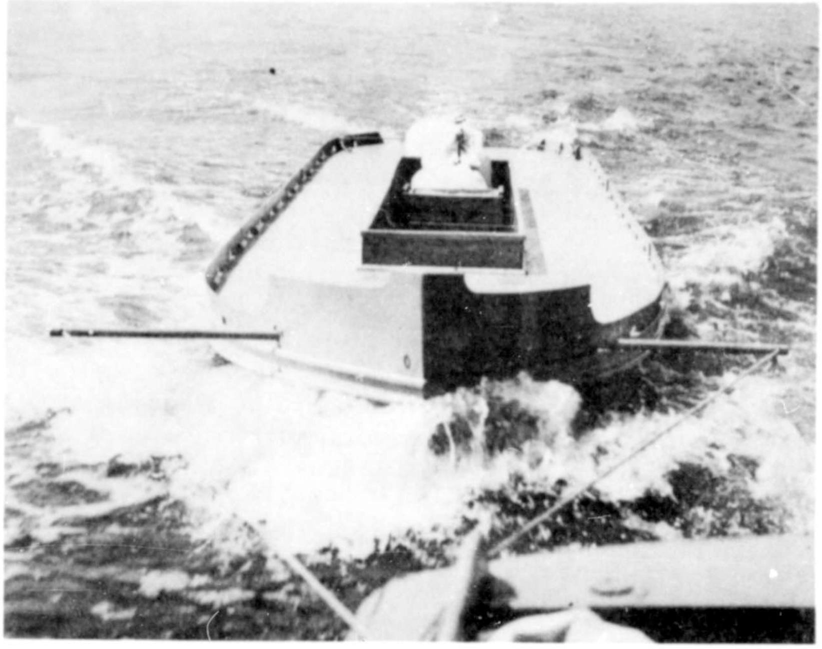


Figure 1. Testing the 25-Foot Model.

The concept of a stern-beaching vessel of the same type as was model tested was discussed with the Bureau of Ships, Department of the Navy. As a result of this discussion, the Bureau of Ships proposed a plan for a stern-beaching vessel, propelled by two vertical-axis propellers located in the forward part of the vessel. After the Bureau of Ships proposal was reviewed, a third concept was developed by USATRECOM of a bow-beaching vessel which would be propelled and steered by two vertical-axis propellers located in the after part of the vessel.

Sufficient information was now available to enter into a design contract. USATRECOM contracted with the Bethlehem Steel Company, Shipbuilding Division, to review the proposed concepts and develop a preliminary design. The concept of a bow-beaching vessel which would be propelled and steered by two vertical-axis propellers located in the after part of the vessel was accepted, and the preparation of contract plans and specifications was undertaken.

While the vessel was under construction, extensive model tests of propulsion systems were conducted by personnel of the David Taylor Model Basin, Washington, D. C., under the auspices of USATRECOM. Tests were made with both the sinusoidal and Rotor "A" blade motion propulsion systems.

Preliminary studies conducted by the Bethlehem Steel Company indicated that at landing displacement a trial speed of 14 knots could be attained with 2,580 horsepower. Test results from the vertical-axis propellers installed in the USAV LTI-2194 indicated this to be within the realm of feasibility (Reference 7). However, self-propelled model tests at the David Taylor Model Basin indicated that a speed of 14 knots at landing displacement would require 4,575 horespower with the sinusoidal linkage and 4,050 horsepower with the Rotor "A" linkage. To obtain propellers in the power range indicated by the model tests would require the development of units larger than previously undertaken. It was felt that the new propellers should be a further development of the LTI-2194 type in order to utilize the experience gained from the use of these propellers, rather than a completely new design. It became apparent that the propellers were going to be a source of delay in construction. In an attempt to avoid or minimize this delay, it was decided to remove the propellers from the LTI-2194 and to install them in the beach discharge lighter until such time as the new propellers became available. This limited the initial installation to 2,000 horsepower. Hence, it was decided to design the new propellers to absorb 1,100 horsepower each and to accept the reduction in speed.

The Pacific Car and Foundry Company was awarded a contract by USATRECOM to evaluate the results obtained with the LTI-2194 propellers, to study the various configurations of vertical-axis propellers, and to develop a design concept. As a result of this evaluation and study, the Pacific Car and Foundry Company was authorized to proceed with the design and construction of two 1,100 horsepower joy-stick-type vertical-axis propellers.

The contract plans and specifications were completed in April 1955, and delivered to the Department of the Navy for construction of the vessel. After a review of the plans and specifications by the Bureau of Ships, a construction contract was awarded to the National Steel and Shipbuilding Corporation in February 1956. The vessel's keel was laid on 7 December 1956, and the vessel was launched and christened "Lt. Col. John U. D. Page" on 28 September 1957.

Upon removal of the propellers from the LTI-2194, it was discovered that the repairs necessary to restore them to a satisfactory operating condition would require approximately the same amount of time as to complete the new propellers. Since little could be gained from installing the LTI-2194 propellers, it was decided to use the new propellers in the initial installation.

The new propellers were delivered to the National Steel and Shipbuilding Corporation in April 1958. The vessel was accepted from the contractor by the Bureau of Ships in November 1958. Upon acceptance of the vessel by the Bureau of Ships, it was delivered to USATRECOM. Engineering tests started with the acceptance trials and were completed in July 1959.

The vessel's behavior at sea and operational characteristics in congested harbors were determined on its voyage from San Diego to San Francisco, California, to Fort Eustis, Virginia. Further confirmation was obtained from operations in the Hampton Roads and Chesapeake Bay area, and from a voyage to France. Beaching tests were conducted at Little Creek, Virginia, and the off-shore operation was conducted at Fort Story, Virginia. Marriage tests with the "USNS Comet" were undertaken in the Chesapeake Bay and off the Virginia Capes. Discharge of the Comet was accomplished in a NODEX operation off the coast of France. Standardization tests with both the sinusoidal and Rotor "A" linkage were conducted by personnel of the David Taylor Model Basin on the course at Kent Island, Maryland. Model Basin personnel also conducted a vibration test in Panama and made a model flow study in their circulating water channel.

DESCRIPTION OF THE BEACH DISCHARGE LIGHTER (BDL-IX)

The Lighter, Beach Discharge, Deck Cargo, Diesel, Steel, 300-Foot, Design 5002 ("USAV Lt. Col. John U. D. Page"), is a vessel of all-welded steel construction having one complete open deck for vehicular storage and a partial deck for crew accommodations. The open deck has a centrally located island containing the navigational spaces, radio room, fan rooms, access to spaces below, and engine exhaust systems. The partial deck, located within the hull below the main deck, contains berthing and messing accommodations for the crew and day space for truck drivers. A ramp is fitted at the bow to permit discharge and loading over the beach. The ramp forms a section of the bow when closed. Also, a hydraulic ram is fitted in the bow, below the ramp, to assist in retraction from the beach. This ram is fitted with a 6-foot-diameter mushroom-type shoe and is capable of exerting a horizontal force of 128,500 pounds. Portable sections are fitted in the bulwark to permit both side and stern loading. The principal characteristics of the vessel are given in Table 1. The vessel is shown in Figure 2.

TABLE 1
CHARACTERISTICS OF THE PAGE

Length, overall	338 ft. 0 in.
Length, between perpendiculars	304 ft. 0 in.
Breadth, at main deck, molded	65 ft. 0 in.
Depth, base line to main deck, molded	21 ft. 0 in.
Design drag of keel	1 to 50

TABLE 1 - contd.

Draft, landing condition, to bottom of keel:	
Forward	4 ft. 0 in.
Mean	7 ft. 0 in.
Aft	10 ft. 0 in.
Draft, ocean condition, to bottom of keel:	
Forward	7 ft. 8 in.
Mean	10 ft. 8 in.
Aft	13 ft. 8 in.
Light ship weight	1,548.8 tons
Displacement to landing waterline, molded	2,340 tons
Displacement to ocean waterline, molded	4,126 tons
Horsepower, maximum continuous rating	2,200 shp
Cruising radius	5,500 miles

Deadweights	Landing Condition (tons)	Ocean Condition (tons)
Diesel oil	87	324
Fresh water	35	136
Lubricating oil	8	8
Stores	25	45
Crew and effects	20	3
Cargo	600	-
Ballast	-	2,045
Total	775	2,561

Accommodations

Captain	1
Chief Engineer	1
Officers	4
Crew	24
Total	30

The vessel is propelled by two 1,200-horsepower diesel engines which drive two vertical-axis propellers. The characteristics of the propeller are given in Table 2.

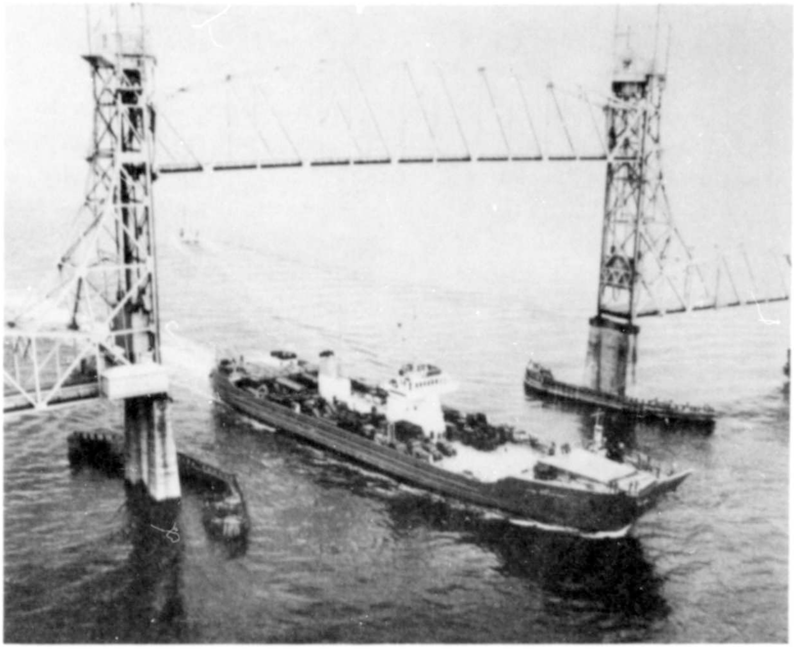


Figure 2. "USAV Lt. Col. John U. D. Page" on Her Maiden Voyage.

TABLE 2
CHARACTERISTICS OF THE VERTICAL-AXIS PROPELLER

Orbit diameter	9 ft. 4 in.
Blade length	4 ft. 6 in.
Number of blades	6
Pitch:	
From	19 ft. 1 in. ahead
To	19 ft. 1 in. astern
Steering angle:	
Forward	90^{o}R to 90^{o}L
Aft	90^{o}R to 90^{o}L
Maximum propeller rpm	76
Maximum propeller input shaft rpm	320
Propeller bevel gear ratio	6.923:1
Steering and pitch control	Hydraulic
Direction of rotation	Outboard

A constant-tensioning device is installed in the after part of the vessel. This device consists of a hydraulic power unit, two tensioning units, and a control stand.

The hydraulic power unit is located in the propeller room and is made up of a bedplate which incorporates a 150-gallon oil reservoir. Mounted on top of the bedplate is a 20-horsepower, 1,200-rpm electric motor with dual shaft extensions driving a high-pressure pump, a low-pressure pump, and a servo pump. The high-pressure pump is a radial piston type which has a normal capacity of 15 gpm at 3,500 psi. The low-pressure pump is of the vane type and has a normal capacity rating of 57.5 gpm at 500 psi; the servo pump is a gear type with a normal capacity of 3.2 gpm at 300 psi. The oil supply for all of the pumps is taken from the reservoir. In addition, a heat exchanger and a compensator valve, which controls the stroke of the high-pressure pump, are provided.

The two tensioning units installed on the main deck consist of 8-inch-diameter cylinders with 72-inch strokes cushioned at both ends. The cylinders are mounted on bedplates which are extended to provide sliding tracks for the hook mechanisms. The hook mechanisms are connected to piston rods and are provided with quick-release features.

The control stand is located at the after steering station. It consists of a four-way, through-position, control-valve lever, operated with detents to maintain the selected position.

The characteristics of the tensioning device are given in Table 3.

TABLE 3
CHARACTERISTICS OF THE CONSTANT-TENSIONING DEVICE

Operation	Load per Cable (lb.)	Approximate Speed (rpm)	Pressure (psi)
Taking up slack	0 - 15,000	15	max. 500
Applying tension	15,000 - 120,000	0 - 2.5	max. 3,000
Maintaining tension	120,000	0	3,000
Overhaul controlled by compensator	120,000 - 150,000	0 - 5	3,000 - 3,500
Overhaul controlled by flow control valves	150,000	15	3,500
Overhaul violent surges	150,000	over 15	3,500

TEST PROCEDURES AND RESULTS

DETERMINATION ONE. Power Capabilities of Propellers Fitted With Sinusoidal and Rotor "A" Propeller Blade Linkage

Procedure

The personnel of the David Taylor Model Basin conducted self-propelled model tests with the sinusoidal linkage at 2, 340-ton displacement and with the Rotor "A" linkage at 2, 340- and 4, 126-ton displacements. Tests with the sinusoidal linkage were conducted at 0.65π and 0.58π pitch. Tests with the Rotor "A" linkage at 2, 340-ton displacement were conducted at 3.15-inch, 2.7-inch, and 2.2-inch eccentricities. At the 4, 126-ton displacement, the test was conducted at a 3.15-inch eccentricity only. Shaft horsepower (shp) and rpm were plotted for all tests. Effective horsepower (ehp) from a previous test was obtained for each displacement. The speed of the advance coefficients (ja) and $\frac{\text{ehp}}{\text{shp}}$ were determined and plotted.

Results

Results of the self-propelled model test are shown in Figures 3 through 6.

DETERMINATION TWO. Acceptability of Vessel

Preliminary acceptance trials were conducted by the National Steel and Shipbuilding Company under the supervision of the U. S. Navy Supervisor of Shipbuilding and the Inspector of Naval Ordnance, Long Beach, California. The trials were witnessed by a trial board, appointed by the Bureau of Ships, Department of the Navy. The acceptance trials consisted of the following tests: standardization under ocean and landing conditions, maneuvering and special tests, endurance and economy tests, ahead steering test, crash stop test, anchor test, beaching test, and after steering station and emergency steering test.

Procedure - Standardization Under Ocean and Landing Conditions

Standardization trials were conducted on the course off La Jolla, California, and consisted of 10 runs over the course at both ocean and landing conditions. Runs were made in each direction at approximately 600, 1,000, 1,400, and 1,800 horsepower, and at full power. During the runs, the main engines and propellers were operated with automatic control of pitch. The steering

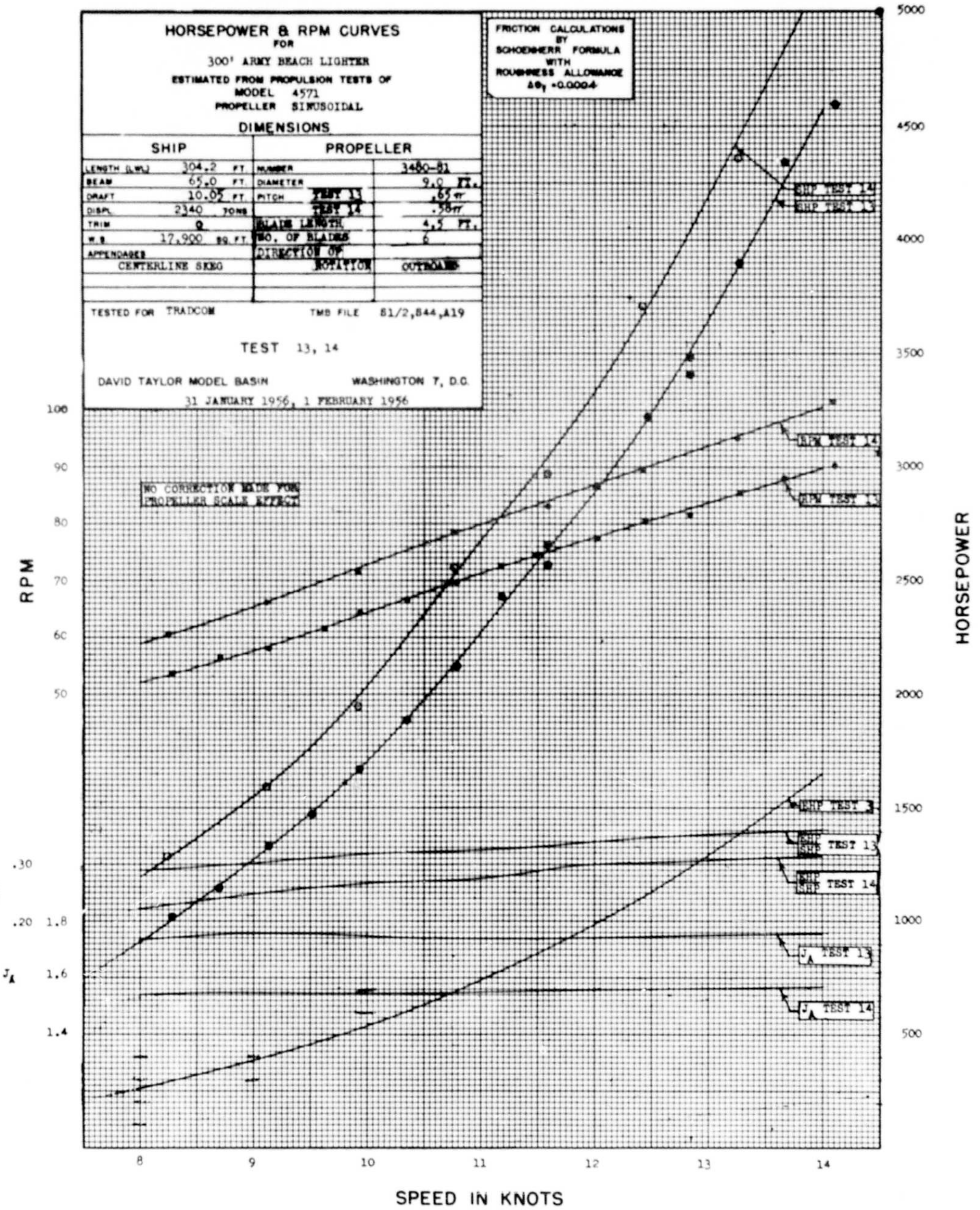


Figure 3. Sinusoidal Blade Linkage at 2, 340-Ton Displacement.

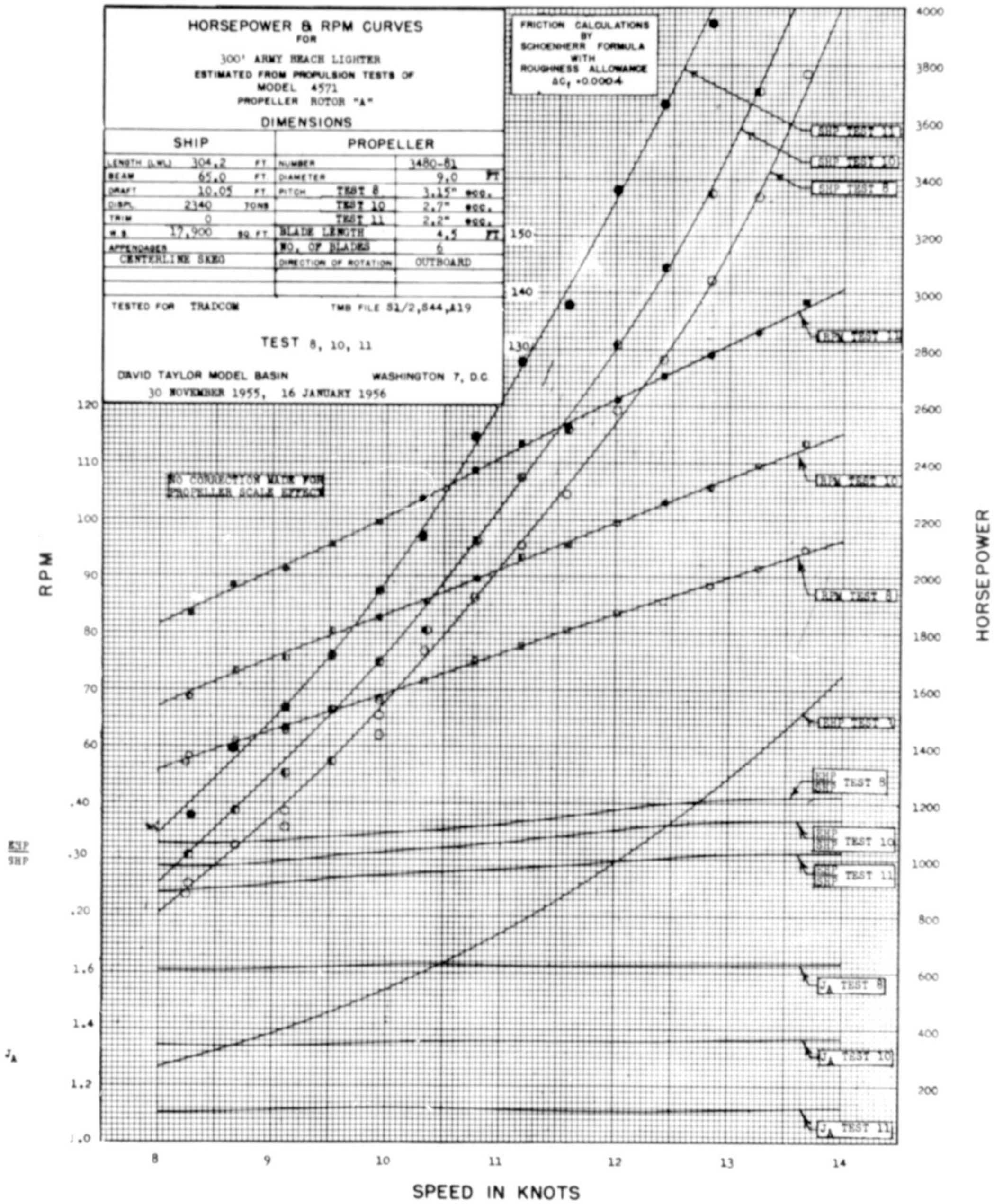


Figure 4. Rotor "A" Blade Linkage at 2,340-Ton Displacement.

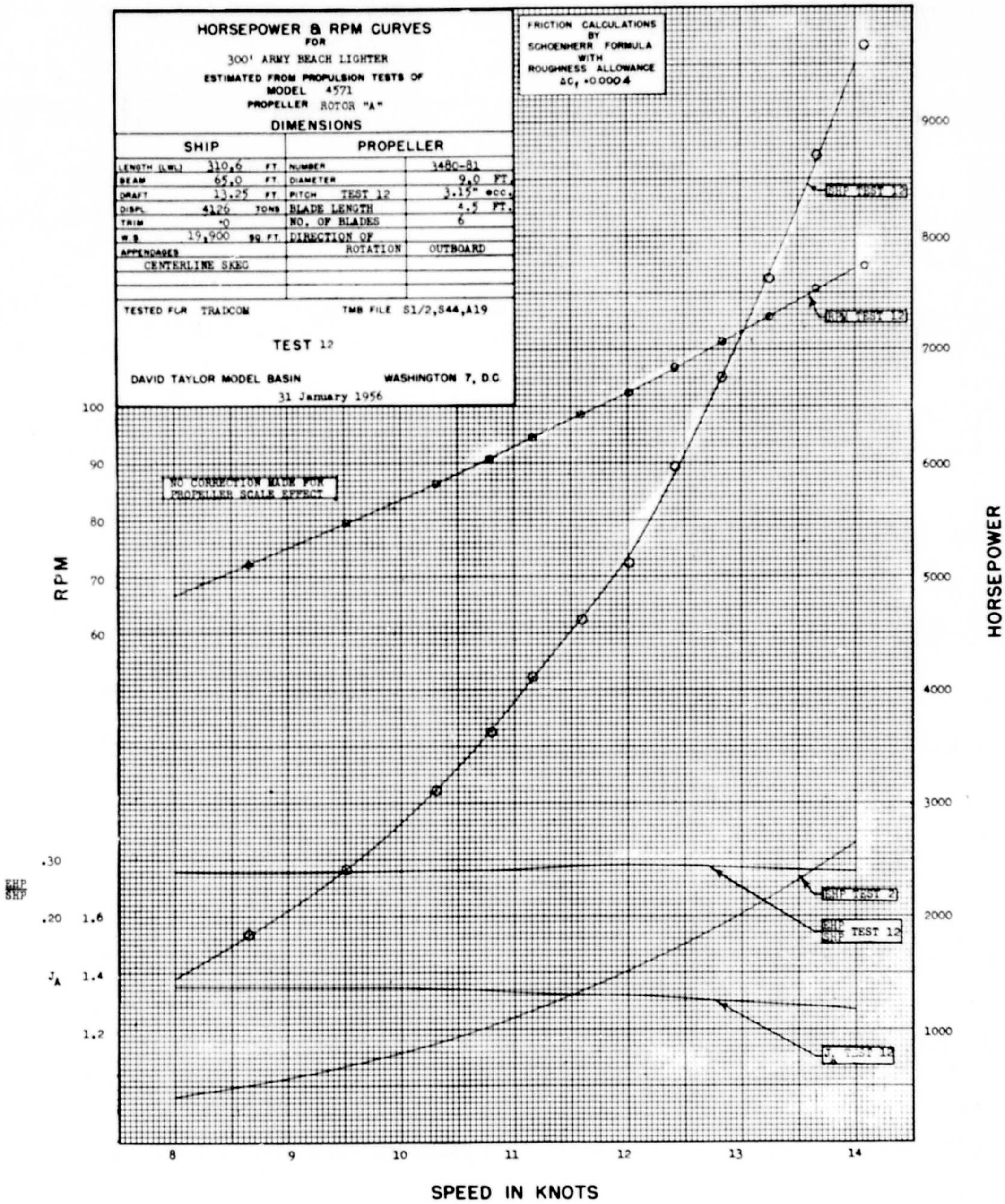


Figure 5. Rotor "A" Blade Linkage at 4,126-Ton Displacement.

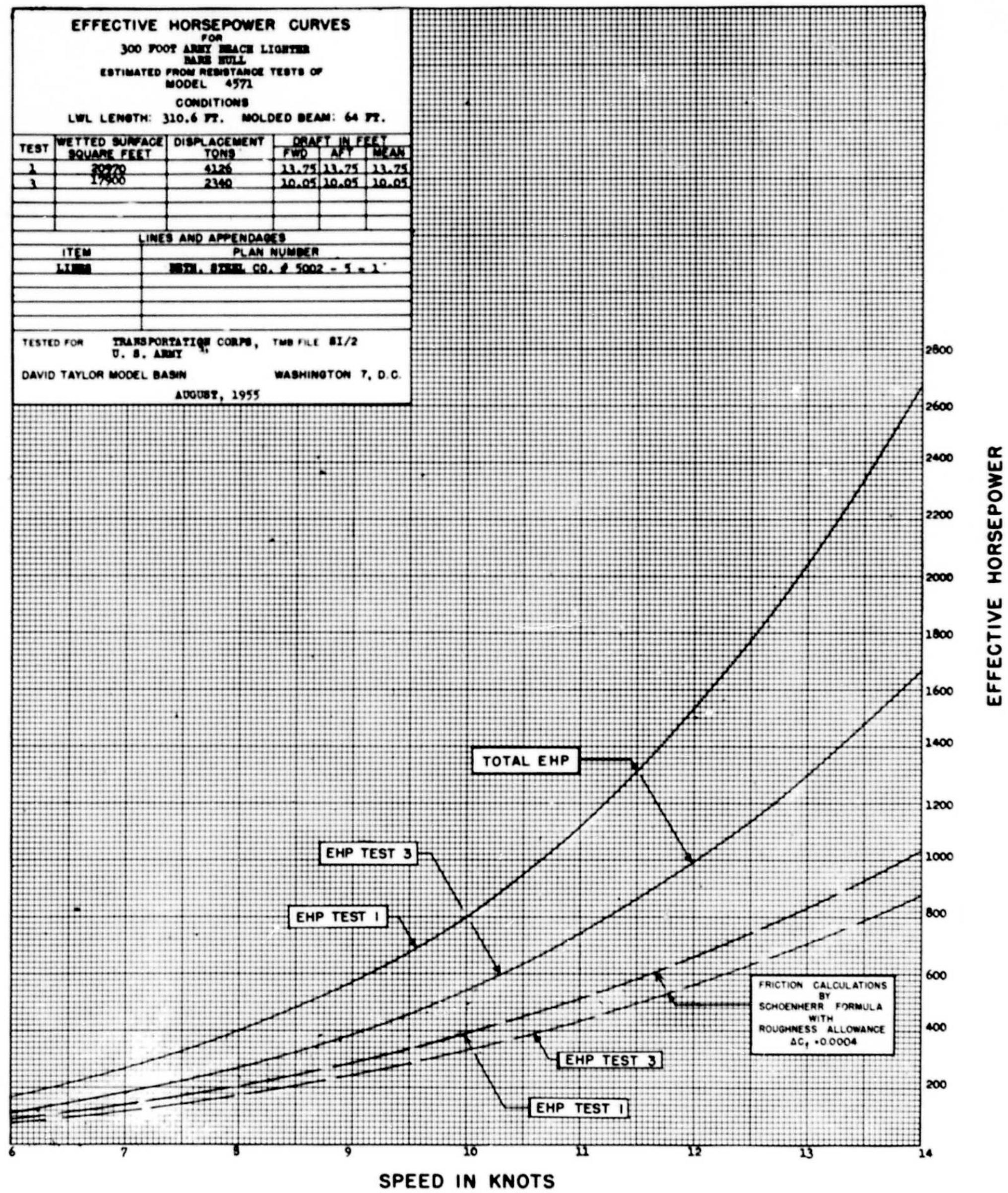


Figure 6. Effective Horsepower (EHP).

was controlled from the bridge. Horsepower and shaft rpm were obtained from David Taylor Model Basin torsionmeters, operated by Model Basin personnel. All other data were taken by personnel from the National Steel and Shipbuilding Corporation. The conditions at the time of the trials were as given in Table 4.

TABLE 4
CONDITIONS DURING ACCEPTANCE TRIALS

	Ocean Condition	Landing Condition
Draft:		
Forward	13 ft. 3 in.	10 ft. 1 in.
Amidships	13 ft. 4 in.	10 ft. 1/2 in.
Aft	13 ft. 5 in.	10 ft. 2 in.
Water density	1.021	1.021
Displacement (long tons)	3,957	2,340
Sea condition	Moderate	Calm
Wind (k.)	SW 15	SSW 10
Current	To North	To North
Sea water temperature ($^{\circ}$F)	70	70
Depth of water (fath.)	75	75

Results

The data obtained are summarized in Tables 5 and 6 and plotted in Figure 7.

TABLE 5
ACCEPTANCE TRIALS: STANDARDIZATION UNDER OCEAN CONDITION

Run	Dir.	Propeller RPM Port	Propeller RPM Stbd.	Propeller RPM Avg.	SHP Port	SHP Stbd.	SHP Total	Speed (k.)	π Pitch Setting	Thrust Angle Port	Thrust Angle Stbd.
1	N	47.38	46.22	46.80	218.6	243.9	462.5	5.75	0.580	5.0°R	5.0°R
2	S	47.52	46.08	46.80	223.1	246.6	469.7	4.92	0.580	5.0°R	5.5°R
Average	-	-	-	46.80	-	-	466.1	5.34	0.580	-	-
3	N	58.64	57.49	58.06	476.2	502.7	978.9	6.96	0.580	5.0°R	8.0°R
4	S	58.64	57.20	57.92	471.0	493.0	964.0	6.37	0.580	5.0°R	0.0°
Average	-	-	-	57.99	-	-	971.4	6.66	0.580	-	-
5	N	67.89	66.30	67.09	760.0	685.8	1445.8	7.83	0.580	5.0°R	0.0°
6	S	66.81	66.30	66.55	754.0	703.7	1457.7	7.27	0.580	5.0°R	0.0°
Average	-	-	-	66.82	-	-	1451.7	7.55	0.580	-	-
7	N	74.68	76.27	75.47	980.0	1007.8	1987.8	8.28	0.570	5.0°R	5.0°R
8	S	74.39	76.27	75.33	988.0	1002.6	1990.6	7.88	0.570	5.0°R	5.0°R
Average	-	-	-	75.40	-	-	1989.2	8.08	0.570	-	-
9	N	76.70	75.83	76.26	1007.1	1084.2	2091.3	8.65	0.570	5.0°R	5.0°R
10	S	76.70	75.83	76.26	1053.1	1083.4	2136.5	8.13	0.560	5.0°R	5.0°R
Average	-	-	-	76.26	-	-	2113.9	8.39	0.565	-	-

TABLE 6

ACCEPTANCE TRIALS: STANDARDIZATION UNDER LANDING CONDITION

Run	Dir.	Propeller RPM Port	Propeller RPM Stbd.	Propeller RPM Avg.	SHP Port	SHP Stbd.	SHP Total	Speed (k.)	π Pitch Setting	Thrust Angle Port	Thrust Angle Stbd.
1	N	50.70	47.38	49.04	265.9	267.9	533.8	7.10	0.560	5.6°R	5.0°L
2	S	48.25	47.38	47.81	258.7	275.5	534.2	6.62	0.580	5.6°R	2.0°L
Average	-	-	-	48.42	-	-	534.0	6.86	0.570	-	-
3	N	58.21	56.77	57.49	470.6	402.3	872.9	8.28	0.580	5.6°R	4.0°L
4	S	59.80	56.62	58.21	517.6	481.7	999.3	8.13	0.580	5.6°R	2.0°L
Average	-	-	-	57.85	-	-	936.1	8.20	0.580	-	-
5	N	65.87	66.60	66.23	694.4	746.6	1441.0	9.18	0.580	5.6°R	3.0°R
6	S	67.17	66.45	66.80	738.5	734.5	1473.0	9.07	0.580	5.6°R	4.0°L
Average	-	-	-	66.51	-	-	1457.0	9.12	0.580	-	-
7	N	71.93	71.93	71.93	895.7	874.6	1770.3	9.68	0.570	5.6°R	4.0°L
8	S	70.49	71.65	71.07	848.4	864.3	1712.7	9.28	0.570	5.7°R	0.0°
Average	-	-	-	71.50	-	-	1741.5	9.48	0.570	-	-
9	N	76.70	75.55	76.12	1100.4	1114.1	2214.5	10.23	0.570	5.7°R	0.0°
10	S	76.70	75.55	76.12	1098.9	1110.3	2209.2	10.20	0.560	5.6°R	0.0°
Average	-	-	-	76.12	-	-	2211.8	10.21	0.565	-	-

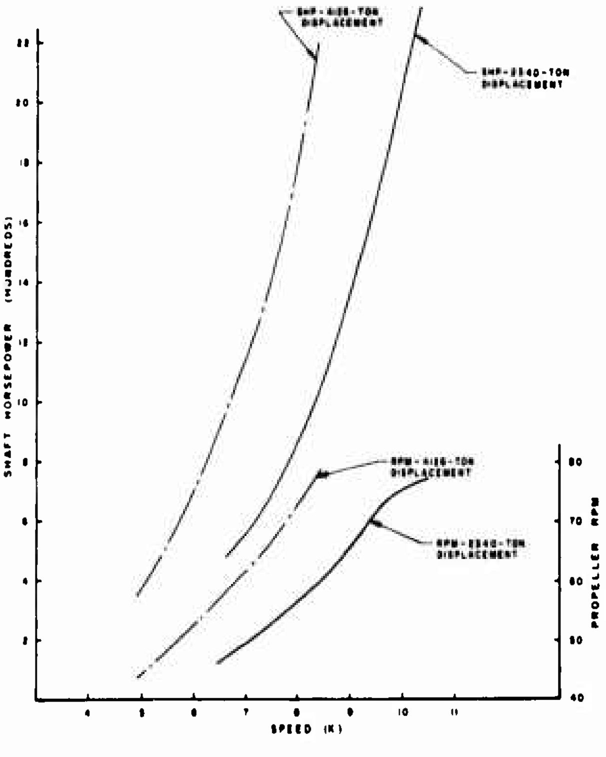


Figure 7. Standardization Under Ocean and Landing Conditions.

Procedure - Maneuvering and Special Tests

The maneuvering and special tests consisted of circle tests and sideways control tests. In conducting the circle tests, the vessel was maneuvered such that it made a series of circles at different speeds and thrust angles. For each circle the vessel was steadied on course at the designated ahead speed, and on command the designated thrust angle was applied and held until the vessel had traversed a complete circle. All of the circles were made to the right except three, which were made to the left at 45-degree thrust angles. Left turns were also made at each engine speed used for the right turns. Turns were also made with one engine thrust directed ahead and the other astern. Duplicate series were run with the vessel in both the ocean and landing conditions.

The sideways control test consisted of operating the vessel with one engine thrust directed ahead and the other astern and adjusting the thrust angles of both units until the vessel moved laterally through the water without making way either ahead or astern. This test was conducted only under the landing condition.

Results

The results of the circle tests are shown in Tables 7 through 9, and the results of the sideways test are shown in Table 10.

TABLE 7
ACCEPTANCE TRIALS: CIRCLE TEST, AHEAD, UNDER OCEAN CONDITION

Thrust Angle (deg.)	Engine Speed (rpm)	Ahead Pitch		Time (min)			
		Port	Stbd.	90°	180°	270°	360°
5°R	450	0.58	0.58	3.06	6.15	8.51	11.31
15°R	450	0.58	0.58	2.12	4.10	6.11	8.14
45°R	450	0.58	0.58	1.35	3.80	4.37	6.22
90°R	450	0.58	0.58	1.24	2.37	3.33	4.31
5°R	600	0.58	0.60	2.23	4.14	6.22	8.39
15°R	600	0.58	0.57	1.30	3.10	4.54	6.23
45°R	600	0.57	0.55	1.80	2.17	3.31	4.50
90°R	600	0.56	0.55	1.11	2.12	3.04	3.48
5°R	750	0.57	0.55	1.55	3.29	5.60	6.46
15°R	750	0.58	0.56	1.20	2.33	3.53	5.26
45°R	750	0.57	0.50	0.56	2.10	3.12	4.10
90°R	750	0.55	0.55	0.58	1.46	2.21	2.59
5°R	850	0.57	0.55	1.54	3.51	5.37	7.19
15°R	850	0.57	0.51	1.12	2.21	3.33	4.55
45°R	850	0.56	0.51	0.54	1.49	2.53	3.48
90°R	850	0.56	0.55	0.51	1.42	2.19	2.51
45°L	450	0.57	0.58	1.30	3.20	5.11	6.41
45°L	600	0.55	0.59	1.80	2.25	3.51	5.30
45°L	850	0.56	0.56	0.56	2.20	3.16	-

TABLE 8
ACCEPTANCE TRIALS: CIRCLE TEST, AHEAD, UNDER LANDING CONDITION

Thrust Angle (deg.)	Engine Speed (rpm)	Ahead Pitch		Time (min)			
		Port	Stbd.	90°	180°	270°	360°
5°R	450	0.58	0.58	3.21	5.54	8.14	10.46
15°R	450	0.58	0.58	1.50	3.38	5.37	7.20
45°R	450	0.58	0.58	1.16	2.46	4.40	5.19
90°R	450	0.57	0.58	1.26	2.25	3.10	3.47
5°R	600	0.58	0.60	2.11	4.12	6.14	8.18
15°R	600	0.58	0.57	1.23	2.50	4.15	5.40
45°R	600	0.57	0.55	0.59	2.40	3.30	4.00
90°R	600	0.56	0.55	1.50	1.53	2.25	2.52
5°R	750	0.57	0.55	1.34	3.36	5.32	7.27
15°R	750	0.58	0.51	1.70	2.25	3.39	5.00
45°R	750	0.57	0.50	0.54	1.51	2.43	3.32
90°R	750	0.55	0.55	0.54	1.36	2.05	2.31
5°R	850	0.57	0.55	1.29	2.49	4.16	5.39
15°R	850	0.57	0.51	1.10	2.15	3.23	4.30
45°R	850	0.56	0.51	0.51	1.43	2.31	3.19
90°R	850	0.56	0.55	0.48	1.27	1.52	2.15
45°L	450	0.57	0.59	1.36	3.10	4.25	5.50
45°L	600	0.55	0.60	1.11	2.13	3.15	4.15
45°L	850	0.56	0.58	0.49	1.50	2.42	3.34

TABLE 9
ACCEPTANCE TRIALS: CIRCLE TEST,
STARBOARD THRUST AHEAD, PORT THRUST ASTERN

Thrust Angle		Engine Speed	Pitch		Time (min)	
Port	Stbd.	(rpm)	Port	Stbd.	180°	360°
		Ocean Condition				
0	0	325	0.43	0.45	*	-
45°L	45°L	325	0.43	0.45	**	-
0	0	600	0.53	0.57	8.40	9.29
45°L	45°L	600	0.52	0.58	6.18	7.26
0	0	850	0.55	0.55	3.29	6.30
45°L	45°L	850	0.55	0.53	3.30	5.34
		Landing Condition				
0	0	325	0.40	0.40	13.25	17.32
45°L	45°L	325	0.40	0.40	8.22	14.47
0	0	600	0.53	0.60	4.90	6.35
45°L	45°L	600	0.53	0.60	4.17	6.14
0	0	850	0.55	0.55	3.21	5.14
45°L	45°L	850	0.53	0.58	2.54	4.31

* Vessel turned 90° only.

** Vessel turned into wind only.

TABLE 10
ACCEPTANCE TRIALS: SIDEWAYS CONTROL
TEST UNDER LANDING CONDITION

Engine Operation				Pitch		Thrust Angle		Vessel Movement
Port		Stbd.						
RPM	Dir.	RPM	Dir.	Port	Stbd.	Port	Stbd.	(dir.)
560	Ahead	630	Astern	0.59	0.59	26°L	37°R	To Stbd.
720	Ahead	720	Astern	0.54	0.50	32°L	37°R	To Stbd.
800	Ahead	800	Astern	0.57	0.52	32°L	36°R	To Stbd.
800	Astern	800	Ahead	0.56	0.50	30°L	24°R	To Port

Procedure - Endurance and Economy Test

The vessel was operated at full power ahead for a period of 4 consecutive hours. During the test, the operation of all the machinery was observed. Pressures and temperatures were recorded; horsepower and rpm were determined with David Taylor Model Basin torsionmeters. The fuel used by the main engines was metered. The firing pressures on all the cylinders of both main engines were taken. Upon completion of the 4-hour ahead test, a 15-minute full-power astern run was made. The endurance and economy tests were made under the ocean condition only.

Results

The rate of fuel consumption is shown in Table 11. The operational conditions for the main propulsion plant, including the horsepower developed, are shown in Table 12. Water and oil pressures and temperatures are shown in Tables 13 through 17, and firing pressures in Table 18.

TABLE 11
ENDURANCE AND ECONOMY TEST: FUEL CONSUMPTION UNDER OCEAN CONDITION

	Ahead															
	Engine RPM		Pitch Setting		SHP		Fuel Oil* Gal. Used		Fuel Oil* Gal./Hr.		Fuel Oil* Lb./Hr.		Fuel Oil* Lb./SHP-Hr.	
Time	Port	Stbd.	Port	Stbd.	Port	Stbd.	Port	Stbd.	Port	Stbd.	Port	Stbd.	Port	Stbd.
0900	840	840	0.58	0.56	1163.6	1142.3	0	0	0	0	0	0	0	0
0930	840	840	0.58	0.55	1154.8	1142.9	36.90	40.80	73.80	81.60	490.03	541.82	0.422	0.474
1000	845	840	0.58	0.58	1125.2	1161.5	72.98	78.84	72.98	78.84	484.58	523.50	0.422	0.456
1030	840	840	0.58	0.58	1134.2	1175.1	109.00	123.54	72.67	82.36	482.53	546.87	0.422	0.473
1100	840	840	0.57	0.58	1111.8	1167.2	144.00	164.34	72.00	82.17	478.08	545.61	0.420	0.471
1130	840	840	0.58	0.58	1105.8	1163.3	180.02	202.38	72.01	80.95	478.15	537.51	0.422	0.464
1200	840	840	0.58	0.58	1105.8	1147.3	216.92	244.02	72.31	81.34	480.14	540.10	0.425	0.467
1230	840	840	0.58	0.58	1095.6	1149.8	251.92	284.82	71.98	81.38	477.94	540.36	0.425	0.467
1300	840	840	0.58	0.58	1105.4	1147.1	288.82	326.46	72.20	81.61	479.41	541.89	0.427	0.469
	Astern													
-	760	840	-	-	1177.6	1187.2	-	-	-	-	-	-	-	-

* Fuel Oil:
Weight - 6.64 pounds per gallon.
Specific gravity - 0.7969.
Heat value - 19,423 Btu per pound.

Specific fuel consumption corrected to 19,350 Btu per pound.
Port - 0.429.
Stbd. - 0.471.

TABLE 12
ENDURANCE AND ECONOMY TEST: HORSEPOWER, RPM UNDER OCEAN CONDITION

		Engine RPM		Shaft RPM		Propeller Input RPM		* Pitch Setting		Engine Rack (mm.)		SHP	
Time	Dir.	Port	Stbd.	Port	Stbd.	Port	Stbd.	Port	Stbd.	Port	Stbd.	Port	Stbd.
0900	Ahead	840	840	815	815	529	525	0.58	0.56	6.8	6.9	1163.6	1142.3
0930	Ahead	840	840	815	815	528	527	0.58	0.55	6.9	7.0	1154.8	1142.9
1000	Ahead	845	840	818	815	530	525	0.58	0.58	6.9	7.0	1125.2	1161.5
1030	Ahead	840	840	815	815	530	525	0.58	0.58	6.9	7.0	1134.2	1175.1
1100	Ahead	840	840	815	815	530	525	0.57	0.58	6.9	7.0	1111.8	1167.2
1130	Ahead	840	840	815	815	530	525	0.58	0.58	7.0	7.0	1105.8	1163.3
1200	Ahead	840	840	815	815	530	525	0.58	0.58	7.0	7.0	1105.8	1147.3
1230	Ahead	840	840	815	815	530	520	0.58	0.58	7.0	7.0	1095.7	1149.8
1300	Ahead	840	840	815	815	530	520	0.58	0.58	7.0	7.0	1105.8	1147.1
1415	Astern	760	840	738	815	511	523	-	-	-	-	1177.6	1187.2

TABLE 13
ENDURANCE AND ECONOMY TEST:
LUBRICATING OIL PRESSURES UNDER OCEAN CONDITION (PSIG)

	Pressures Lubricating Oil									
	Main Engine					Hydraulic Coupling				Reduction
	Pump	Strainer		Filter		Drive Unit		Strainer		Gear Cooler
Time	Out	In	Out	In	Out	In	Out	In	Out	In
				Port - Ahead						
0900	48	37	31	48	50	14	20	11	7	9
0930	47	38	32	47	50	12	15	8	4	9
1000	47	37	31	47	50	11	15	8	4	9
1030	47	37	31	47	50	11	15	8	4	8
1100	47	37	31	47	50	12	16	8	4	8
1130	47	37	31	47	50	12	16	9	5	8
1200	48	37	31	47	50	12	16	9	5	8
1230	48	37	31	47	50	12	16	9	5	8
1300	48	37	31	47	50	13	17	10	5	8
				Port - Astern						
1415	47	36	30	45	47	15	17	12	7	8
				Starboard - Ahead						
0900	42	41	41	32	28	11	20	16	10	9
0930	41	41	41	32	28	11	20	15	9	9
1000	41	42	42	32	28	11	19	15	9	9
1030	41	41	41	32	28	10	18	15	8	9
1100	41	42	42	32	28	10	18	14	8	9
1130	41	41	41	32	28	10	18	14	8	9
1200	41	42	42	32	28	10	19	15	8	9
1230	41	42	42	32	28	10	18	14	8	9
1300	41	42	42	32	28	10	18	14	8	9
				Starboard - Astern						
1415	41	42	42	32	28	11	20	15	9	9

TABLE 14
ENDURANCE AND ECONOMY TEST: FUEL OIL, COMPRESSED AIR, AND WATER PRESSURES UNDER OCEAN CONDITION (PSIG)

	Fuel Oil		Compressed Air		Fresh Water	Salt Water
	Filter		Control Air	Scavenger	Pump	Pump
Time	In	Out	Pressure	(in. H_2O)	Discharge	Discharge
			Port - Ahead			
0900	42	28	104	3.50	30	5
0930	40	30	102	3.25	30	5
1000	41	30	103	3.25	30	5
1030	41	29	104	3.25	30	6
1100	41	29	104	3.25	30	6
1130	41	29	104	3.25	30	6
1200	41	30	104	3.25	30	6
1230	41	30	104	3.25	30	6
1300	39	30	104	3.25	29	6
			Port - Astern			
1415	37	26	104	3.25	27	6
			Starboard - Ahead			
0900	40	30	104	3.25	29	8
0930	40	31	102	3.25	29	8
1000	39	31	103	3.25	28	8
1030	39	31	104	3.25	28	8
1100	39	31	104	3.25	28	8
1130	40	31	104	3.25	29	8
1200	39	31	104	3.25	28	8
1230	39	31	104	3.25	28	8
1300	40	31	104	3.25	28	8
			Starboard - Astern			
1415	40	31	104	3.25	28	8

TABLE 15

ENDURANCE AND ECONOMY TEST: OIL AND WATER TEMPERATURES UNDER OCEAN CONDITION (°F)

	Lubricating Oil			Fresh Water			Sea Water			
	Main Engine		Reduction Gear	Main Engine		Lubricating Oil Cooler	Main Engine Fresh Water Cooler		Hydraulic Coupling Lubricating Oil Cooler	
Time	To	From	From	To	From	To	In	Out	In	Out
					Port - Ahead					
0900	154	172	145	146	152	150	68	76	68	76
0930	154	172	155	146	152	150	68	76	68	76
1000	156	172	160	146	152	150	68	76	68	76
1030	156	174	163	146	152	150	68	76	68	76
1100	156	172	165	146	152	150	68	78	68	78
1130	156	172	167	146	152	150	68	78	68	78
1200	156	172	168	146	152	150	68	78	68	78
1230	156	174	170	146	152	150	68	78	68	78
1300	156	172	170	146	152	150	68	78	68	78
					Port - Astern					
1415	156	172	170	146	154	150	68	78	68	78
					Starboard - Ahead					
0900	160	180	135	154	162	142	68	73	68	73
0930	160	180	135	154	162	150	70	76	70	76
1000	160	180	140	154	162	150	70	76	70	76
1030	160	180	143	154	162	150	70	76	70	76
1100	160	180	144	154	162	150	70	76	70	76
1130	160	180	145	154	162	150	70	76	70	76
1200	160	180	146	154	162	150	70	76	70	76
1230	160	180	148	154	162	150	70	76	70	76
1300	160	180	148	154	162	150	70	76	70	76
					Starboard - Astern					
1415	160	180	148	154	162	152	70	76	70	76

TABLE 16

ENDURANCE AND ECONOMY TEST: MAIN ENGINE EXHAUST TEMPERATURES UNDER OCEAN CONDITION (°F)

	Cylinder Number						
Time	1	2	3	4	5	6	Stack
			Port - Ahead				
0900	820	780	820	800	840	780	770
0930	840	780	820	800	820	780	770
1000	800	760	800	780	810	760	760
1030	800	740	780	780	800	760	755
1100	800	740	800	780	800	760	760
1130	800	760	800	760	800	740	755
1200	780	740	780	740	800	740	745
1230	800	740	780	740	800	740	750
1300	780	740	780	760	800	740	750
			Port - Astern				
1415	860	820	840	820	860	820	775
			Starboard - Ahead				
0900	780	780	780	820	800	830	770
0930	770	790	780	820	780	820	770
1000	780	790	800	820	800	820	765
1030	760	770	780	810	780	810	765
1100	770	770	780	820	800	830	770
1130	760	770	770	810	780	830	770
1200	750	750	760	810	790	820	765

TABLE 16 - contd.

Time	Cylinder Number 1	2	3	4	5	6	Stack
1230	760	770	770	810	800	820	770
1300	750	770	760	780	800	810	770
			Starboard - Astern				
1415	760	780	780	810	810	830	770

TABLE 17

ENDURANCE AND ECONOMY TEST: MAIN SHAFT BEARING TEMPERATURES UNDER OCEAN CONDITION (°F)

Time	Bearing Location Frame 36	Frame 37	Frame 38	Frame 39	Frame 40	Frame 41
			Port - Ahead			
0900	115	111	115	111	133	118
0930	120	116	120	116	138	124
1000	124	120	124	120	142	127
1030	126	122	126	122	143	127
1100	127	122	127	122	144	130
1130	127	124	130	126	148	130
1200	129	126	130	126	144	133
1230	130	126	130	126	144	133
1300	130	126	130	127	144	135
			Port - Astern			
1415	130	126	130	127	144	135
			Starboard - Ahead			
0900	109	109	109	111	124	126
0930	109	122	112	112	124	126
1000	112	126	116	115	127	129
1030	115	126	118	118	131	131
1100	115	127	118	120	131	136
1130	116	129	118	120	133	136
1200	118	129	122	122	134	136
1230	118	129	122	124	136	136
1300	118	129	122	124	136	136
			Starboard - Astern			
1415	118	129	122	124	136	136

TABLE 18

ENDURANCE AND ECONOMY TEST: MAIN ENGINE FIRING PRESSURES UNDER OCEAN CONDITION (PSIG)

Engine	Cylinder 1	2	3	4	5	6
Port	1050	1105	1110	1090	1130	1105
Stbd.	1125	1120	1120	1090	1110	1090

Procedure - Ahead Steering Test

With the vessel at full-power ahead and steady on course, the direction of thrust was changed from 0 degrees to 90 degrees right, from 90 degrees right to 90 degrees left, from 90 degrees left to 90 degrees right, and 90 degrees right to 0 degrees. The number of turns of the steering wheel and the time required for the propeller to respond were recorded. Upon completion of this maneuver the vessel was steadied on course. The direction of thrust was changed from 0 degrees to 90 degrees right and held until the vessel's heading changed 360 degrees. The vessel was again steadied on course, and the thrust was changed from 0 degrees to 90 degrees left and held until the vessel's heading changed 360 degrees. The tests were conducted under the ocean condition only.

Results

Changing the direction of thrust from amidships (0 degrees) to hard right (90 degrees) required two revolutions of the steering wheel with a propeller response of 3 seconds. Changing from 90 degrees right to 90 degrees left and from 90 degrees left to 90 degrees right each required 5 revolutions of the steering wheel. In both cases, the propeller response was 6 seconds. Two revolutions of the steering wheel were required to change from 90 degrees right to 0 degrees with a response of 3 seconds. When the direction of thrust was changed from 0 degrees to 90 degrees and the vessel was permitted to make a complete turn, a turn of 360 degrees to the right was made in 2 minutes 50 seconds and 360 degrees to the left in 2 minutes 40 seconds. In both cases, the diameter of the turning circle was about one vessel length.

Procedure - Crash Stop Test

With the vessel ballasted to ocean condition and operating at full-power ahead, the pitch control was changed from full ahead to full astern. The vessel was operated at full astern for a period of 15 minutes. The pitch control was then changed from full astern to full ahead. The test was repeated to verify the results.

Results

The performance during the crash stops was judged to be exceptional and is charted in Table 19. However, at full-power astern, with the helm amidships, the vessel would not maintain a steady course.

TABLE 19
CRASH STOP TEST UNDER OCEAN CONDITION

No.	Event	Ahead Run 1	Ahead Run 2	Astern Run 1	Astern Run 2
1	Reach in ship lengths	1-3/4	1-1/3	3/4	3/4
2	Time from control shift until ship is dead in water	1 min. 24 sec.	1 min. 15 sec.	0 min. 52 sec.	0 min. 52 sec.
3	RPM	840	840	830	830
4	SHP	1145	1160	1105	1110
5	Full pitch to zero pitch	0 min. 02 sec.	0 min. 02 sec.	0 min. 02 sec.	0 min. 02 sec.
6	Zero pitch to full pitch in opposite direction	0 min. 06 sec.	0 min. 06 sec.	0 min. 06 sec.	0 min. 06 sec.

Procedure - Anchor Test

With the vessel dead in the water, the starboard anchor was lowered 60 fathoms with the windlass. The anchor was then hoisted to 45 fathoms and held with the electric brake. The brake was then released and the anchor was hoisted until it was clear of the water. It was then released and allowed to run freely for 60 fathoms. During the free run it was stopped at 15-fathom intervals with the hand brake. The anchor was then housed. The same procedure was repeated with the port anchor. All measurements were taken at the water's edge.

Results

The chain ran freely on both anchors, and the anchors housed without difficulty. Both the electric and hand brakes stopped and held the anchors satisfactorily. The performance of the windlass is shown in Table 20.

TABLE 20
PERFORMANCE OF WINDLASS DURING ANCHOR TEST

Chain Out (fath.)		Hoisting Time (min.)		Motor Temp. (°C)		Motor Voltage		Motor Amps.		Hoisting Speed Aver. (fpm.)	
Port	Stbd.	Port	Stbd.	Port	Stbd.	Port	Stbd.	Port	Stbd.	Port	Stbd.
45	45	0	0	30	30	450	450	21	23	0	0
30	30	2.55	2.50	31	31	450	450	20	18	23.53	24.00
15	15	5.45	5.40	31	31	450	450	19	15	33.03	33.33
0	0	8.40	8.30	31	31	450	450	19	15	32.14	32.53

Procedure - Beaching Test

The vessel was ballasted to landing displacement and was beached twice at Coronado, California. Prior to beaching,the engine-cooling water was shifted to the machinery-cooling water tanks, and the engines were cooled by the recirculation of the water through these tanks throughout the entire operation. The vessel was beached at a speed of about 5 knots. After beaching, the ramp was lowered and raised. The vessel was then retracted by using both the engines and the retraction ram. At the time of beaching there was about a 7-foot surf and the tide was rising. The beach gradient at the location of the first beaching was 1 foot in 10 feet, and 1 foot in 33 feet at the second location. Upon the completion of the beaching test, the ramp was raised with the emergency hand pump.

Results

During the beaching and retracting operations, it was observed that the vessel had no tendency to broach. It was also noted that the vessel could be maneuvered as desired at any time during both operations. The vessel was on the beach for a period of 15 minutes on the first beaching and 25 minutes on the second. In the first retraction test, the vessel was broken free of the beach and was afloat in 42 seconds; both the main engines and the retraction ram were used. The main engines were operated at 700 rpm with a propeller pitch settingof 5.6π.Three cycles of the retraction ram were used. Lowering the ramp required 2 minutes 50 seconds, and raising the ramp required 2 minutes 40 seconds. Raising the ramp with the emergency hand pump required 16 minutes 15 seconds. During the test, the main engines, refrigeration plant, and one generator were operated for a period of 2 hours on the machinery-cooling water tanks. The temperature of the water in the tanks increased 5° F.

Procedure - After Steering Station and Emergency Steering Test

The steering control and pitch control were transferred from the bridge to the after steering station; the propulsion units were controlled from this station. The emergency steering was conducted from the propeller room using sound-powered telephones for communication with the bridge. Steering was accomplished with one propeller only. The pitch controls were set in the ahead position; and upon a signal from the bridge, the emergency steering linkage was assembled on the port propeller. The pneudyne was then disconnected, and the vessel was steered by the emergency system on directions from the bridge. The procedure was repeated with the starboard propeller.

Results

Steering of the vessel from the after steering station was difficult as a result of the one-to-one ratio of the steering wheel movement to the change of thrust direction, and the lack of a thrust angle indicator. Conning of the vessel from the after steering station was limited because of the lack of visibility.

The vessel can be steered with one propeller using the emergency linkage; however, the emergency linkage will permit operation only in the event of failure of the air control system or of the pneudynes. It does not provide a method of operation in the event of failure of the electric power or of the hydraulic system.

DETERMINATION THREE. Behavior of Page at Sea and in Congested Harbors

Procedure

The vessel departed from the Oakland Army Terminal, Oakland, California, on 24 February 1959, for Fort Eustis, Virginia, via the Panama Canal, and arrived at Fort Eustis on 17 April 1959. During the voyage, the behavior of the vessel was observed, and the periods of roll and pitch were determined under various weather conditions and at different displacements.

Results

It was observed that the vessel handles easily in congested areas. Docking and undocking maneuvers were accomplished without assistance from tugs or other craft. At sea, the vessel proved to be comfortable, to ride easily, and to show little tendency to pound. Course keeping in a seaway was difficult, and large thrust angles were required. As a result of these large changes in the direction of thrust, the vessel's forward speed was considerably reduced. The bow of the vessel has a tendency to "fall off" in above-moderate winds. Beam winds have a considerable effect on the vessel's ability to maintain course as a result of the large sail area. The motion of the vessel in a seaway is easy and is not considered excessive. The periods of roll and pitch are shown in Tables 21 and 22.

TABLE 21
PERIOD OF ROLL

Run	Displacement	Sea Condition	Wind Condition Vel.	Wind Condition Dir.	Vessel Course (deg.)	Vessel Speed (k.)	Min. Roll (deg.)	Max. Roll (deg.)	Aver. Period (sec.)
1	3600 L/T	Moderate	5k	SE	120	10	3	10	5.9
2	2600 L/T	Moderate	6k	NE	117	9	4	10	6.0
3	3200 L/T	Moderate	20k	E	350	8	4	10	5.5
4	3600 L/T	Rough	40k	NW	0	8	4	5	5.0

TABLE 22
PERIOD OF PITCH

Run	Displacement	Sea Condition	Wind Condition Vel.	Wind Condition Dir.	Vessel Course (deg.)	Vessel Speed (k.)	Pitch (deg.)	Aver. Period (sec.)
1	2600 L/T	Moderate	20k	ENE	120	9	4	6.0
2	3600 L/T	Rough	40k	NNW	0	-	8	5.5

DETERMINATION FOUR. Source of Bulkhead Vibration

Procedure

During the voyage from San Diego, California, to Balboa, Canal Zone, excessive vibration was discovered in the plating panels of the shaft alley longitudinal bulkheads. The amplitudes of the vibration appeared to increase with the engine speed and the filling of ballast tanks 6 and 7.

On 5 March, a rupture was discovered in the starboard longitudinal bulkhead of the number 7 centerline tank. The rupture was curved, approximately 3 inches long, and was located adjacent to the upper after bracket of the number 5 shaft bearing pedestal. At the time of the discovery of the fracture, the number 7 centerline tank was filled to a height of 13 feet 6 inches. The ballast was immediately shifted from the number 7 centerline tank to the number 6 centerline tank. The ballast prior to the fracture and after transfer was as shown in Table 23.

TABLE 23
BALLAST CONDITION, 5 MARCH

	Prior To Fracture						After Fracture					
	Port		Centerline		Starboard		Port		Centerline		Starboard	
Tank	(ft.)	(in.)	(ft.)	(in.)	(ft.)	(in.)	(ft.)	(in.)	(ft.)	(in.)	(ft.)	(in.)
1	-	10	-	8	-	10	-	10	-	8	-	10
2	12	4	-	10	10	5	12	4	-	10	10	5
3	7	1	-	8	7	1	7	1	-	8	7	1
4	7	8	-	8	7	6	7	8	-	8	7	6
5	8	10	-	-	8	10	8	10	-	-	8	10
6	16	4	4	6	16	2	16	4	14	0	16	2
7	13	4	13	6	13	8	13	4	1	6	13	8

On 6 and 7 March, the ballast was transferred. On 7 March, it was noted that the length of the fracture in the number 7 centerline tank had increased to 4 inches. A stop-hole was drilled at the top of the fracture. Also, it was discovered that a 4-inch horizontal fracture had occurred in the number 7 port tank bulkhead, approximately 4 feet above the shaft alley catwalk and 4 feet aft of frame 39. Stop-holes were drilled at both ends of the fracture.

On 8 March, in an attempt to reduce vibration, the engine speed was reduced from 850 rpm to 825 rpm, and then further reduced to 800 rpm; the pitch was reduced to 0.575π. The ballast was again transferred to obtain a light ship condition. A semicircular fracture was discovered in the port longitudinal bulkhead of the number 7 centerline tank. This fracture was located at the weld edge where the 4-inch fill line penetrates the bulkhead. The fracture extended from the top of the pipe to the after lower quarter, approximately 135 degrees. The ballast condition on the days following the discovery of the fracture is given in Table 24. On 9 March, the engine speed was further reduced to 750 rpm and was later returned to 800 rpm.

TABLE 24
BALLAST CONDITION, 6-8 MARCH

Date	Tank	Port (ft.)	Port (in.)	Centerline (ft.)	Centerline (in.)	Starboard (ft.)	Starboard (in.)
6 March	1	-	10	-	8	-	10
	2	4	11	-	10	-	-
	3	7	1	-	8	7	1
	4	7	8	-	8	7	6
	5	8	10	-	-	8	10
	6	16	4	4	5	16	2
	7	13	4	1	6	13	8
7 March	1	-	10	-	8	-	10
	2	4	11	-	10	-	-
	3	7	1	-	8	6	0
	4	7	8	-	8	7	6
	5	8	10	-	-	8	10
	6	16	4	5	6	16	2
	7	13	4	1	6	13	8
8 March	1	-	-	-	-	-	-
	2	-	-	-	-	-	-
	3	-	-	-	-	-	-
	4	-	-	-	-	-	-
	5	8	10	-	-	4	6
	6	11	6	8	6	11	6
	7	7	0	5	3	7	0

On 10 March, a 4-inch fracture was discovered in the port longitudinal bulkhead of the number 7 centerline tank, about 4 feet aft of the semicircular fracture. The fracture was located in a horizontal weld of a bracket from the number 4 shaft bearing pedestal.

Upon the arrival of the vessel at Cristobal, Canal Zone, a vibration survey was conducted by David Taylor Model Basin personnel (Reference 1). Two CEC-type velocity meters, which could be moved to any position in the aft area of the vessel, were arranged so that their outputs were simultaneously recorded by a "Sanborn" recorder. Vibration measurements were taken for 18 selected positions; these were mainly concentrated at the port tanks. Underway tests were made at displacements of 3,050 and 2,950 long tons. During both tests, the number 6 and 7 centerline tanks were full. The number 6 and 7 port and starboard tanks were full for the 3,050-ton test and empty for the 2,950-ton test. An anchor drop test was made in an attempt to excite the natural hull frequencies. In addition, natural frequencies of bulkhead panels and sections of the line shafting were excited either by use of the David Taylor Model Basin midget vibration generator or by shock exciting the structure.

As a result of the vibration survey, the personnel of the David Taylor Model Basin were authorized to conduct a wake survey in their circulating water channel (Reference 2). A model of the vessel was fitted with vertical-axis propellers, and flow studies were conducted. The model was fitted with tubes for the injection of dye and wool yarn tufts to indicate the direction of the flow. On the same test, air was injected through the tubes and/or propeller housing to make the vortex motions more clearly visible. During the test, the model was ballasted to represent a displacement of 4,126 long tons. Tests were conducted for blade motions and pitch settings as shown in Table 25.

TABLE 25
BLADE MOTIONS USED IN WAKE SURVEY

Type Of Motion	Nominal Pitch	Compensation (deg.)	Steering Angle (deg.)	Rotation
Sinusoidal	0.58π	9.0	4.0	Outward
Sinusoidal	0.65π	10.0	4.0	Outward
Sinusoidal	0.65π	10.0	4.0	Inward
Sinusoidal	0.65π	5.0	4.0	Outward
Rotor "A"	3.15 in. ecc.	7.0	2.5	Outward
Rotor "A"	3.15 in. ecc.	2.0	2.5	Outward
Modified Cycloidal	0.65π	2.5	-6.0	Outward

Results

The results of the vibration survey are as follows:

1. The bulkhead plating of the fully loaded ballast tanks in the area of the shaft alleys vibrated at blade or double-blade frequency with large amplitudes at 830 engine rpm and 0.55π pitch setting.

2. At 700 engine rpm or at a reduced propeller pitch setting of 0.50π at 830 engine rpm, these vibrations were reduced considerably.

3. Vibration of the bulkheads of the empty tanks is at acceptable levels for all test conditions.

4. The shafting system vibrations are at acceptable levels at all speeds, even though lateral natural frequencies of the forward and aft lineshaft are in near resonance with blade and double-blade frequencies at 830 engine rpm.

5. The propeller housing vibrated with sharply increasing amplitudes (with increase in ship speed) at blade frequencies for pitch settings larger than 0.50π and at 830 engine rpm.

The wake survey test showed that the rotary motion of a vertical-axis propeller produces a vortex system. The system comprises a vortex filament extending aft from near zero orbit angle and a vortex within the blade circle, also near zero orbit angle (Figure 8).

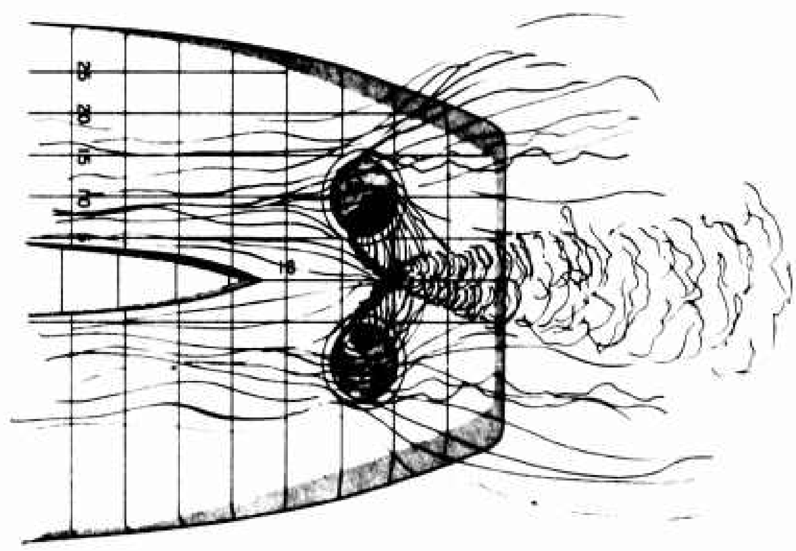


Figure 8. Flow in Way of Vertical-Axis Propeller.

It was also concluded that the vortex system was the only phenenomenon observed which might conceivably be a source of blade frequency vibratory forces. The strength of the system depends on the magnitude of the angles of attack in the fourth quadrant of the rotor orbit circle and may be minimized by reducing these angles of attack. Of the two motions available for use on the BDL-1X, the Rotor "A" type is superior to the sinusoidal motion in that not as much reduction is needed in the angles of attack.

DETERMINATION FIVE. Performance of Vessel During Beaching Operations

Procedure

Prior to the beaching test, 20 vehicles and a quantity of palletized cargo were loaded aboard the vessel. The combined weight of the vehicles and cargo was 355 tons. The vehicles which were loaded consisted of the following:

1 each	20-ton mobile crane
2 each	semitrailers (gasoline tank) M131E1
2 each	5-ton truck tractors, M52
5 each	1/4-ton utility trucks (jeep), M38
3 each	2-1/2-ton cargo trucks, M35
3 each	5-ton trucks, medium wrecker, M62
1 each	Caterpillar tractor, D-8
1 each	rough-terrain forklift, 10,000 pounds
1 each	tank, M46
1 each	surf crane
3 each	semitrailers (tank transporter), M15
3 each	10-ton truck tractors, M123

All the vehicles could be turned around on the vessel's deck except the semitrailers (tank transporter, M15). The cargo was loaded at the after end of the deck (Figure 9).

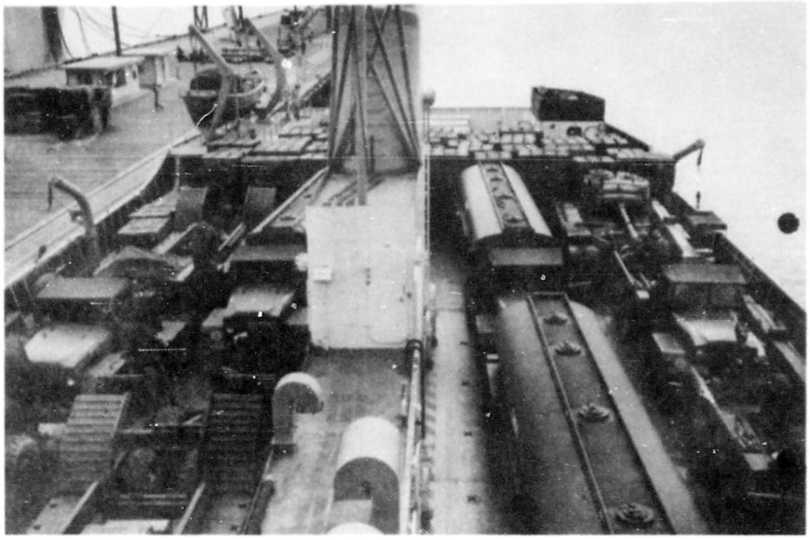


Figure 9. Vehicles and Palletized Cargo Stowed on Deck of Page.

All beachings were made in the vicinity of Anzio Beach Number 2 at Little Creek, Virginia. In this area, the beach gradient is approximately 1 to 47. Prior to beaching, the number 1 centerline ballast tank was filled, and the ballast was pumped as necessary to free the vessel upon retraction. Approaches to the beach were made at several engine speeds, varying from 600 to 850 engine rpm. Retraction was made by working the vessel off the beach with the propellers. The beaching procedure was as follows: the vessel was run on the beach, the ramp was lowered, the vehicles were off-loaded and reloaded, the ramp was raised, and the vessel was retracted from the beach.

Results

During the loading of the vehicles on the vessel, it was noted that the tank treads damaged the studs and nuts of the deck manholes. To prevent this damage, a protection ring (Figure 10) was fabricated and installed on all manholes in areas where tanks or other tracked vehicles would be maneuvered.

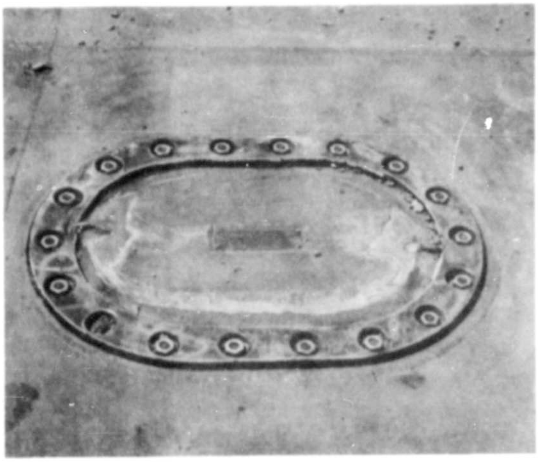


Figure 10. Protection Ring Installed on Manhole Cover.

When the vessel grounded on the beach, the depth of water at the end of the ramp averaged from 3-1/2 to 4 feet. In order to drive the vehicles to the beach, it was necessary to build a sand causeway from the beach to the vessel's ramp (Figures 11 and 12). This condition will exist on any flat beach, as the vessel's landing draft forward is 4 feet 0 inches.

Figure 11. Bulldozer Building Sand Causeway to Ramp of Vessel.

Figure 12. Tank Proceeding up Ramp of Vessel.

During the reloading operation, the wheeled vehicles encountered difficulty in rolling over the end of the ramp because of its thickness. Neither the wheeled nor the tracked vehicles experienced any difficulty in climbing or descending the ramp.

The vessel demonstrated exceptional maneuverability and control. The wind, current, and surf had very little effect on the vessel. At no time was a tendency to broach noted. The vertical-axis propellers were capable of working the vessel off the beach and retracting through the surf with complete control of the vessel. Neither stern anchors nor other assistance was required.

The average time for off-loading a vehicle from ship to beach was 2 minutes. The cargo was moved from aft to the forward part of the vessel by tractor. It was then transported to the beach by a rough-terrain forklift. Moving a draft of cargo from the vessel to the beach averaged 4 minutes.

The results of the beaching test are given in Table 26.

TABLE 26
PERFORMANCE DURING BEACHING TEST

Run	Wind Dir (deg.)	Wind Vel (k.)	Tide	Surf	Current Dir. (deg.)	Current Vel. (k.)	Vessel Course (deg.)	Approach Speed (eng. rpm)	Retraction Time (min.)	Remarks
1	SE	10	Flood	None	280	0.40	204	650	33.0	(1)
2	SW	12	Ebb	None	070	0.13	200	830	210.0	(2)
3	SW	20	Flood	None	280	0.20	200	830	18.0	(3)
4	SW	20	Flood	None	280	0.20	200	840	7.0	(3)
5	SW	20	High	None	000	0.00	200	840	10.0	(4)
6	NW	16	Ebb	1.5'-2.0'	070	0.60	202	840	21.0	(5)
7	E	10	Flood	1.0'-1.5'	280	0.70	200	850	20.0	(6)
8	ESE	12	Ebb	1.0'-1.5'	070	0.16	200	600	13.5	(7)
9	SE	13	Ebb	Slight	070	1.70	203	600	23.0	(6)
10	SE	15	Ebb	Slight	070	0.50	213	600	16.0	(8)
11	S	13	Flood	Slight	280	0.60	193	820	22.0	(3)
12	SW	14	Flood	Slight	070	1.30	197	600	2.0	(9)

Remarks:
(1) Bulldozer and rough-terrain lift off-loaded. Sand causeway built to ramp for reloading rough-terrain forklift, this was necessary because of the thickness of the ramp-end.
(2) Causeway built for off-loading. Vehicles bogged down in soft sand. Vehicles towed to firm ground and driven to Little Creek for reloading. Vessel grounded by ebbing tide. Main engines secured periodically to prevent overheating.
(3) No vehicles off-loaded.
(4) Rough-terrain forklift and jeep off-loaded and reloaded.
(5) No vehicles off-loaded because of surf.
(6) No vehicles off-loaded because of depth of water at end of ramp.
(7) Vehicles off-loaded. Vehicles were assisted to the beach by the tank because of depth of water at end of ramp and beach conditions. No attempt made to reload vehicles.
(8) Several vehicles off-loaded. Vehicles assisted to firm ground by bulldozer and tank.
(9) Vessel grounded approximately 200 feet from shore. Causeway built by bulldozer. Cargo off-loaded by rough-terrain forklift. Vehicles on beach were on-loaded.

DETERMINATION SIX. Suitability of Vessel for Off-Loading Alongside

Procedure

The Page, loaded with 24 drafts of palletized cargo, departed from Fort Eustis, Virginia, and rendezvoused with the "MS Hickory Knoll", a C1-M-AVI type vessel, at sea off Fort Story, Virginia. The Page approached the anchored Hickory Knoll on her port side and was secured alongside. The 24 pallets were off-loaded from the Page to the Hickory Knoll and reloaded from the Hickory Knoll using the Hickory Knoll's cargo gear. During the test, the weather was fair and the sea was calm; the wind velocity was 0.9 knot.

Results

This test established that the vessel can be used for off-loading alongside, for both general cargo and heavy lifts.

The approach and securing of the Page alongside the Hickory Knoll were accomplished in 10 minutes.

The 24 drafts of cargo were off-loaded from the Page to the Hickory Knoll in 27 minutes and were reloaded in 32 minutes.

DETERMINATION SEVEN. Suitability of Page for Marriage With Comet

General

The marriage test with the Comet was conducted in four phases. First, wave tests of the models of the two vessels moored together were conducted at the Stevens Institute of Technology Experimental Towing Tank. A second test was then conducted at the Towing Tank in an attempt to predict the forces and motions between the two vessels. A full-scale test was then conducted in the Chesapeake Bay. Finally, in the NODEX 21 operation, vehicles were discharged from the Comet to the beach discharge lighter and transported to the beach.

Procedure - Model Test in Waves (Reference 5)

Since the roll-on/roll-off principle of landing vehicles on a beach involves the marriage of a deep-draft ocean vessel and a shallow-draft beaching vessel, it was imperative that the motions of the two vessels in waves be investigated. Also, the feasibility of mooring the two vessels together had to be determined. The models of the two vessels were constructed to a scale of 1/8 inch = 1 foot. The models were ballasted so as to have rolling and pitching characteristics comparable to the full-size vessels. Bilge keels were fitted on the Comet model. Tests were first conducted to determine the natural periods of rolling in still water, both individually and when married. The models were then married and were tested at different headings to waves of various proportions. Mooring arrangements consisted of transverse lines over pulleys, which prevented relative transverse movements, and a single fore-and-aft line at each side, connected by pulleys to hanging weights; these represented five-part tackles and a constant-tension mooring winch. A five-section ramp extended from the deck of the Comet model to the deck of the beach discharge model. The arrangement of the mooring gear and ramp is shown in Figure 13.

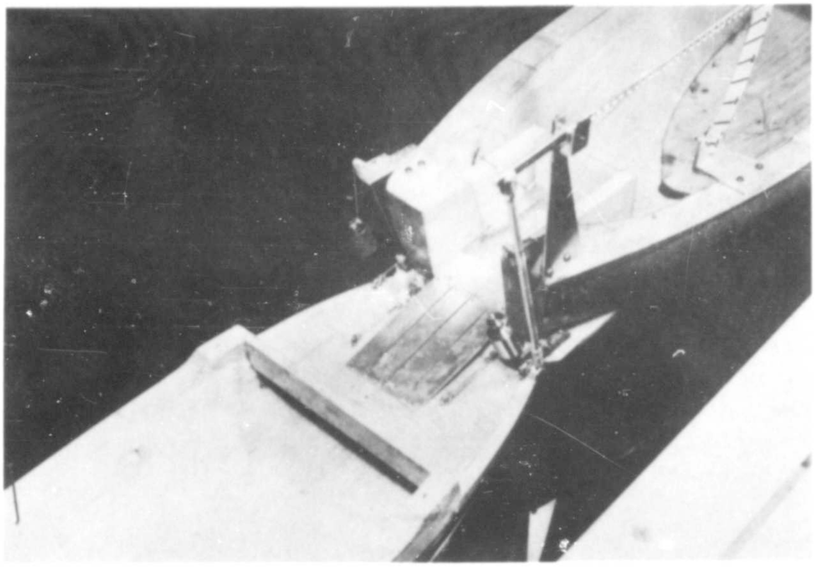


Figure 13. Mooring Arrangements With Page and Comet Models.

Results

It was found that the two vessels had very different rolling characteristics. The periods were widely separated, and the beach discharge lighter dampened out much more quickly than the Comet. Rolling characteristics are shown in Table 27.

TABLE 27
ROLLING CHARACTERISTICS OF VESSELS

	Period of Roll (sec.)	
Vessel	Model	Full Scale
Comet	1.61	15.8
Page	0.58	5.7
Vessels married	1.11	10.9

It was assumed that the marriage of the two vessels could be made only under ideal sea conditions with waves not in excess of 1 to 2 feet high. However, relative motions did not become severe until much higher waves had been reached. The results which were observed are summarized in Table 28.

TABLE 28
BEHAVIOR OF VESSELS MARRIED IN WAVES

Wave Size (full scale, ft.)	Condition	Relative Motion (full scale, ft.)	Remarks
2 x 60	Drifting, head on and diagonal	Negligible	Behavior excellent.
6 x 80	Drifting, head on, diagonal, abeam	± 1	Behavior good.
	Anchored, head on	$\pm \frac{1}{2}$ to ± 1	Behavior good.
	Anchored, 30° heading	± 1	Behavior good.
12 x 160	Anchored, head on	$\pm 1\frac{1}{2}$	Behavior good.
12 x 160 Irregular	Anchored, head on	± 3 to ± 4	Deck of lighter often hit under side of ramp.
10 x 300	Anchored, head on	± 2 to ± 3	Deck of lighter occasionally hit ramp. Vessels occasionally pulled apart.
8 x 500	Anchored, head on	± 7 to ± 8	Lighter hit ramp often and severely.
8 x 500	Anchored, head on, Comet trimmed 2 ft. by head	± 5	Motion worse. All rigging and ramp came apart.
4 x 500	Anchored, head on	$\pm 3\frac{1}{2}$	Behavior better.
4 x 1000	Anchored, head on	± 3	Behavior good.

In some cases of moderate vertical motion, there was also noticeable horizontal motion; this resulted in separation of the two vessels, followed by impact. This suggested the necessity of a method of mooring in which the two vessels would not come in contact. Hence, an outrigger arrangement, as shown in Figure 14, was tried. This arrangement made it evident that mooring could be accomplished under more severe conditions if the two vessels were not allowed to come in contact. When this condition is maintained, the primary limitation is the amount of vertical motion that can be permitted before the deck of the beach discharge lighter hits the ramp.

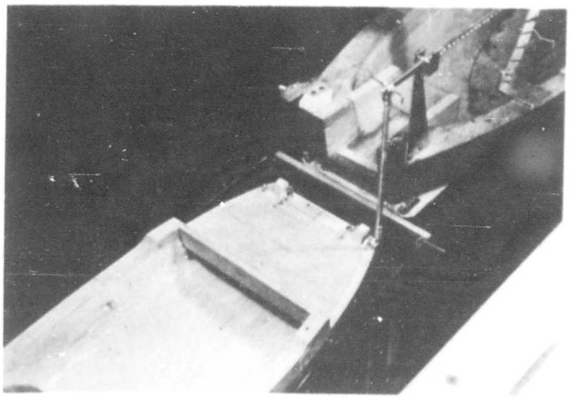


Figure 14. Page and Comet Models With Outrigger Arrangement.

Procedure - Prediction of Motions and Forces From Model Test (Reference 6)

The models used in the first part of the test were ballasted to obtain the designed trims and the realistic longitudinal radii of gyration. Experimental fittings were attached to each model to provide vertical and horizontal motion restraint between the models as was required for the various test conditions. A cantilever spring fitted with a differential transformer was mounted on the Comet model so that either vertical or horizontal forces acting between the two models could be transmitted to a recording oscillograph. Tests were conducted for four wave sizes as follows: 12 feet by 160 feet, 11 feet by 300 feet, 1 foot by 500 feet, and 7 feet by 1,000 feet. At each wave size, tests were conducted to determine the following:

1. The relative motion amplitudes, vertical and horizontal, with the models disconnected at a 20-foot separation.

2. The horizontal force between the models with free relative vertical motion at a 20-foot separation.

3. The horizontal force between the models with zero relative vertical motion at a 20-foot separation.

4. The vertical force between the models at a 2-foot separation with zero relative horizontal motion. The zero relative vertical motion, the partially restrained relative vertical motion (obtained by using a sliding friction brake), as well as the relative vertical motion were also determined.

For conditions when the models were not connected, it was determined that under wave action each model should be free to oscillate fore and aft (surge) but not to drift relative to the ground; thus a desired average separation would be maintained at all times. This was accomplished by leading a towline from each model over a pair of fixed pivot pulleys to a hanging towing weight of predetermined amount. For the condition when the models were connected for measurement purposes, a single towline from the Comet model was loaded with a weight which would permit surge but prevent drift.

Results

Test results expanded to prototype vessel size are given in Tables 29 and 30. A correlation between vertical force and relative vertical motion for the four wave sizes used in the test is shown in Figure 15.

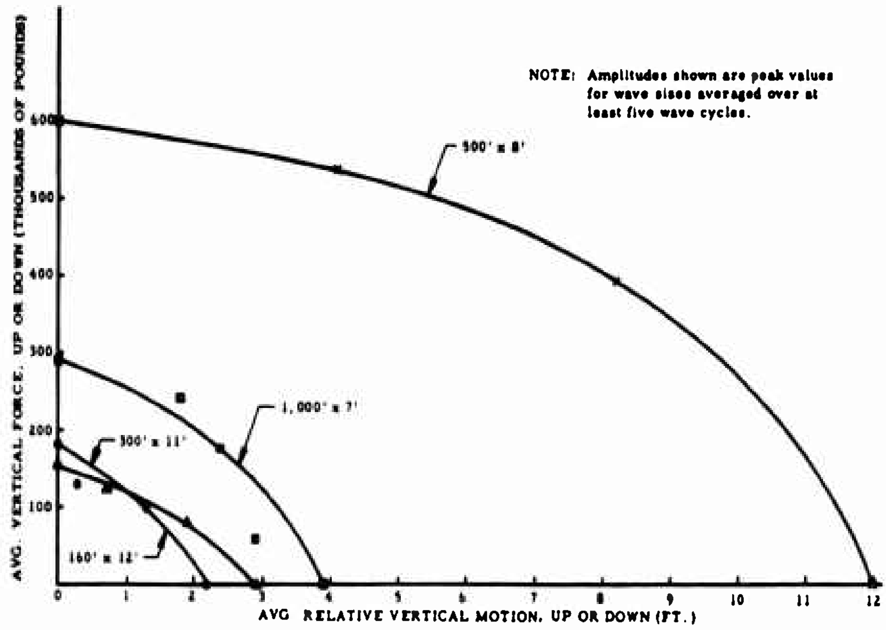


Figure 15. Vertical Force and Relative Vertical Motion of Page and Comet.

TABLE 29
VERTICAL MOTION AND FORCES OF PAGE AND COMET, VESSELS STERN TO STERN AT 20-FOOT SEPARATION

Type of Wave	Condition	Fore-and-Aft Force (lb.) Compression	Tension	Average
Regular 12-ft. x 160-ft. waves. Free relative fore-and-aft motion. 0.4-ft. double amplitude.	Free relative vertical motion.	60,000	93,000	76,000
	Zero relative vertical motion	72,000	81,000	77,000
Regular 11-ft. x 300-ft. waves. Free relative fore-and-aft motion. 0.9-ft. double amplitude.	Free relative vertical motion.	58,000	65,000	62,000
	Zero relative vertical motion.	49,000	46,000	48,000
Regular 8-ft. x 500-ft. waves. Free relative fore-and-aft motion. 4.2-ft. double amplitude.	Free relative vertical motion.	329,000	506,000	417,500
	Zero relative vertical motion.	96,000	100,000	98,000
Regular 7-ft. x 1000-ft. waves Free relative fore-and-aft motion 10.6-ft. double amplitude.	Free relative vertical motion.	146,000	165,000	156,000
	Zero relative vertical motion.	150,000	150,000	150,000

TABLE 30
VERTICAL MOTION AND FORCES OF PAGE RELATIVE TO COMET, VESSELS STERN TO STERN AT 2-FOOT SEPARATION

Type of Wave	Condition	Upward Motion (ft.)	Upward Force (lb.)	Downward Motion (ft.)	Downward Force (lb.)	Average Motion (ft.)	Average Force (lb.)
Regular 12 ft. x 160 ft.	Free relative motion	1.9	0	2.4	0	2.2	0
	Zero relative motion	0	174,000	0	188,000	0	181,000
	Zero relative fore-and-aft motion, partially restrained relative vertical motion						
	Case 1	0.3	132,000	0.3	125,000	0.3	129,000
	Case 2	1.3	97,000	1.3	99,000	1.3	98,000
Regular 11 ft. x 300 ft.	Free relative motion	2.4	0	3.3	0	2.9	0
	Zero relative motion	0	148,000	0	162,000	0	155,000
	Zero relative fore-and-aft motion, partially restrained relative vertical motion						
	Case 1	0.7	113,000	0.6	134,000	0.7	124,000
	Case 2	2.1	65,000	1.6	95,000	1.9	80,000
Regular 8 ft. x 500 ft.	Free relative motion	11.7	0	12.2	0	12.0	0
	Zero relative motion	0	598,000	0	602,000	0	600,000
	Zero relative fore-and-aft motion, partially restrained relative vertical motion						
	Case 1	2.2	559,000	6.0	523,000	4.1	536,000
	Case 2	5.8	456,000	10.3	325,000	8.2	391,000
Regular 7 ft. x 1000 ft.	Free relative motion	3.7	0	4.1	0	3.9	0
	Zero relative motion	0	274,000	0	300,000	0	287,000
	Zero relative fore-and-aft motion, partially restrained relative vertical motion						
	Case 1	1.9	233,000	1.7	250,000	1.8	242,000
	Case 2	2.7	164,000	2.1	192,000	2.4	178,000
	Case 3	3.4	58,000	2.4	62,000	2.9	60,000

Procedure - Marriage Test (Reference 4)

The marriage test with the Comet was conducted in the Chesapeake Bay. This test consisted of the following 15 runs.

Run 1

With the Comet anchored, the Page approached on a course parallel to the Comet's heading, approximately 50 feet off the Comet's port side. When the stern of the Page was abeam the stern of the Comet, the Page was stopped. Two heaving lines, to which messenger lines were attached, were passed from the Comet to the Page. The messenger lines were attached to mooring lines on the Page. These mooring lines were hauled aboard the Comet, and the Comet attempted to warp the Page to her stern. The Page was maneuvered to assist in the warping.

Run 2

With the Comet anchored, the Page backed down to the Comet from a position approximately three ship lengths astern of the Comet. After the Page began making sternway, the port anchor was dropped and used as a drag to steady the vessel on course. As the Page approached the Comet, messenger lines were passed from the Comet to the Page. The messenger lines were secured to mooring lines on the Page, and these lines were hauled aboard the Comet. An attempt was made to warp the Page to the Comet with the Page's nylon mooring lines. Two wire-rope lines were then passed from the Comet to the Page, and the Page was warped to the Comet's stern. As soon as the Page was against the Comet's stern, the two wire-rope mooring pendants were passed from the Comet to the Page and secured to the Page's constant-tensioning devices. After tension was applied to the mooring pendants, the Comet's ramp was lowered to the Page's deck.

Run 3

With the Comet anchored, the Page approached the Comet's stern at an angle of approximately 90 degrees from the Comet's port side, swung her stern into alignment with the Comet, and backed down until she was close enough to the Comet to permit the passing of messenger lines. The messenger lines were fastened to the Comet's wire-rope warping lines, which were then hauled aboard the Page and secured. After the Comet had warped the Page to her stern, the mooring pendants were passed and secured, and the Comet's ramp was lowered to the Page's deck.

Run 4

With the Comet anchored, the Page approached the Comet on a course parallel to the Comet and approximately 50 feet off the starboard side. Messengers, with the Comet's wire-rope warping lines attached, were passed from the Comet to the Page. The warping lines were secured, the Page was maneuvered and warped to the Comet's stern, the mooring pendants were passed and secured, and the Comet's ramp was lowered to the Page's deck.

Run 5

With the Comet anchored, the Page approached the Comet from the port side on a course approximately 45 degrees across the Comet's stern. When the stern of the Page was approximately 25 feet from the Comet, lines were passed from the Comet to the Page. The Page was then warped to the Comet's stern and secured, and the Comet's ramp was lowered to the Page's deck.

After the ramp was lowered, all the vehicles were off-loaded to the Page. In addition, one 18-ton van was off-loaded from and on-loaded to the Comet.

Run 6

With the Comet underway, the Page approached the Comet from the bow on her starboard side. Lines were passed from the Comet to the Page, and the Page was warped to the Comet's stern. After the mooring pendants were passed and secured, the Comet continued towing the Page until the mooring pendants were released. At the time of the tie-up, the Comet was maintaining a speed of 3 knots. This speed was later reduced to 1.7 knots to determine if steerage could be maintained.

Run 7

With the Comet at anchor, the Page approached the Comet on a course parallel to and approximately 50 feet off the Comet's starboard side. A line was fired from the Page to the Comet. This line was attached to the Comet's warping lines, which were then hauled aboard the Page and secured. After the Page was warped to the Comet's stern and secured, the Comet's ramp was lowered. The ramp was then raised, and a 90-degree thrust was applied to the Page's propellers. The Page swung the Comet 90 degrees from her original heading.

Run 8

With the Comet at anchor, the Page approached the Comet on a course parallel to and approximately 50 feet off the Comet's starboard side. A line was fired from the Page to the Comet; the warping lines were attached, hauled aboard, and secured to the Page. The Page was then warped to the Comet's stern and secured, and the Comet's ramp was lowered.

Run 9

With the Comet anchored, the Page approached the Comet on a course parallel to and approximately 50 feet off the Comet's starboard side. Lines were passed from the Comet to the Page, and the Page was warped to the Comet's stern and secured.

Run 10

With the Comet at anchor, the Page approached from the bow and passed along the Comet's port side. At a position approximately three ship lengths astern of the Comet, the Page began to back to the Comet. As the Page approached the Comet, a line fired from the Page missed. A line was then fired from the Comet to the Page, and the warping lines were passed and secured. The attempt to warp the Page to the Comet's stern was unsuccessful.

Run 11

With the Comet at anchor, the Page took a position approximately two ship lengths astern and backed down to her. Upon approaching the Comet, a line was fired from the Page and attached to the Comet's warping lines. The Page was warped to the Comet's stern and secured, and the Comet's ramp was lowered. Vehicles were off-loaded from the Comet to the Page.

Run 12

With the Comet at anchor, the Page approached parallel to and approximately 50 feet off the Comet's starboard side. A line was fired from the Page to the Comet; and the warping lines were attached, hauled aboard, and secured to the Page. After the Page was warped to the stern of the Comet, secured, and the ramp lowered, eight vehicles were off-loaded to the Comet.

Run 13

Both vessels moved to the ocean side of Cape Charles, Virginia. With the Comet at anchor, the Page approached on a course parallel to the Comet's heading and passed 50 feet off the starboard side. Lines were passed from the Comet to the Page, and the Page was warped to the Comet's stern and secured. The ramp was lowered, the angles and clearances were checked, and seven different types of vehicles were driven aboard the Comet.

Run 14

With the Comet at anchor, the Page approached the Comet on a course parallel to and approximately 50 feet off the Comet's starboard side. Lines were passed from the Comet to the Page, and the Page was warped to the Comet's stern and secured. The Comet's ramp was lowered, and the vehicles were off-loaded to the Page.

Run 15

Both vessels returned to the original site in the Chesapeake Bay. The Comet was anchored and the Page approached the Comet parallel to and approximately 50 feet off the Comet's starboard side. Lines were passed from the Comet to the Page, and the Page was warped to the Comet's stern and secured. The Comet's ramp was lowered, and the vehicles were off-loaded to the Comet and reloaded to the Page.

Tests were conducted with the vessels ballasted so as to obtain the maximum and minimum ramp angles. The vehicles were loaded and off-loaded in such a manner as to determine their ability to negotiate extreme and normal ramp angles. Weather conditions and vessel drafts during the test are shown in Table 31. The vehicles used in the test are listed in Table 32.

TABLE 31
WEATHER CONDITIONS AND DRAFTS DURING MARRIAGE TEST

	Wind			Current		Drafts			
						Page		Comet	
Run	Dir	Vel. (k.)	Sea Condition	Dir	Vel (k.)	Fwd.	Aft.	Fwd.	Aft
*1	-	-	-	S	1.90	-	-	-	-
2	ESE	14-16	Slight	S	1.10	4' 8"	10' 6"	17' 0"	17' 0"
3	ESE	14-16	Slight	S	0.70	4' 8"	10' 6"	17' 0"	17' 0"
4	ESE	14-16	Slight	N	0.75	4' 8"	10' 6"	17' 0"	17' 0"
5	NNE	6-10	Calm	S	1.00	4' 6"	9' 6"	15' 6"	19' 0"
6	NNE	2-4	Calm	N	0.50	4' 6"	9' 6"	15' 0"	19' 8"
7	NNE	2-4	Calm	N	0.60	4' 6"	9' 6"	15' 0"	19' 8"
8	WNW	10-12	Calm	S	1.00	4' 6"	9' 6"	14' 5"	19' 8"
9	WNW	10-12	Calm	S	1.40	4' 6"	9' 8"	14' 2"	20' 4"
*10	-	-	-	S	0.70	-	-	-	-
11	W	10	Calm	S	0.70	4' 6"	9' 8"	14' 2"	20' 4"
12	W	10	Calm	Slack	0.00	4' 6"	9' 8"	14' 2"	20' 4"
13	SE	7	Smooth	S	1.40	4' 8"	10' 2"	14' 2"	20' 0"
14	SE	8	Calm	S	0.35	5' 0"	10' 0"	14' 6"	20' 0"
15	NNW	5	Smooth	S	0.40	4' 6"	13' 6"	17' 0"	17' 6"

* No data taken on runs 1 and 10 as marriage was not completed

TABLE 32
LIST OF VEHICLES LOADED DURING MARRIAGE TEST

Number (each)	Description	Capacity (tons)	Type	Weight (each, lb.)
2	Truck, medium wrecker	5	M62	33,325
2	Semitrailer, gasoline tank	12	M131E1	12,400
1	Semitrailer, stake and platform	12	M127	13,500
5	Truck-tractor	5	M52	18,313
3	Truck, cargo	2-1/2	M35	12,465
1	Bulldozer		D-8	46,000
2	Truck, utility	1/4	M38	2,665
1	Tank		M46	92,000
1	Semitrailer, tank transporter	45	M15	42,370
1	Truck-tractor	10	M123	32,490
1	Crane, mobile truck mounted	20		56,850
Total: 20				362,378

Results

The tests demonstrated that the marriage of the Comet and the Page (see Figure 16) is feasible under moderate weather conditions, and that vehicles in general use by the Army can be driven from one vessel to the other over any obtainable ramp angle. The constant-tensioning devices were found to be satisfactory and capable of securing and releasing the vessel under any foreseeable operating condition.

Figure 16. Marriage of Page and Comet.

During the approach, positioning, warping, and securing of the Page, line handling should be held to a minimum. The tie-up could be made from any approach that was attempted. The approach to be used should be based on the weather conditions prevailing at the time. The Comet has a tendency to yaw considerably when at anchor. This makes the parallel approach more difficult than an approach from astern of the Comet. During the astern approach, the Page's bow had a tendency to fall off; this creates a difficult maneuvering condition in the event of a beam wind. The initial line may be fired from either vessel.

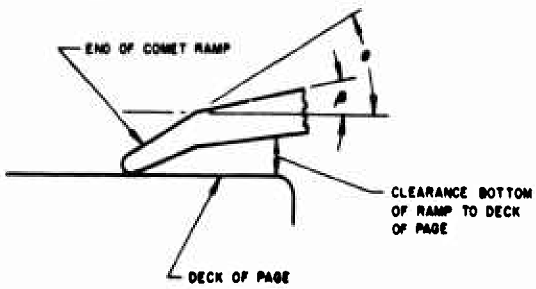
In Run 7, 24 minutes was required for the Page to swing the Comet 90 degrees around her anchor. During the maneuver, the constant-tensioning device maintained a constant tension of 110,000 pounds on each of the mooring pendants. The vessels were held firmly together, and there was no tendency for the Page to slip or inch along the rubber fenders on the Comet.

Tie-up time, ramp angles, and ramp clearances during the marriage test are shown in Table 33.

TABLE 33
TIE-UP TIME, RAMP ANGLES, AND RAMP CLEARANCE DURING MARRIAGE TEST

Run	Tie-Up Time (min.)	Loading Time To Comet (min.)	Loading Time To Page (min.)	Mooring Pendant Tension (lb.)	Ramp Angle (deg.) B	Ramp Angle (deg.) θ	Clearance Port	Clearance Stbd.	Remarks
1	-	-	-	-	-	-	-	-	-
2	20.0	-	-	114,000	6.3	19.3	4' 5"	4' 10"	(1)
3	10.0	-	-	114,000	6.5	19.5	4' 5"	4' 10"	(1)
4	5.0	-	-	114,000	6.5	19.5	4' 5"	4' 10"	(1)
5	12.5	90.0	-	114,000	5.0	18.0	3' 1"	2' 9"	(2) (3)
6	5.0	-	-	110,000	-	-	-	-	(2)
7	6.0	-	-	110,000	-	-	-	-	(1)
8	8.0	-	-	110,000	-1.4	11.6	1' 1-1/2"	1' 4-1/2"	(2)
9	6.0	-	-	110,000	-	-	-	-	(2)
10	-	-	-	-	-	-	-	-	-
11	3.5	-	14	110,000	-0.9	12.1	1' 3"	1' 7-3/4"	(2) (4)
12	5.0	8.5	-	-	1.1	14.1	2' 2-1/2"	2' 6"	(1) (5)
13	4.0	16.0	-	110,000	1.7	14.7	2' 3-1/2"	2' 4"	(2) (6)
14	12.0	-	62	110,000	0.6	13.6	1' 8"	2' 1-1/2"	(1) (7) (8)
15	4.5	22.0	26	110,000	12.4	25.4	7' 0"	7' 5"	(1)

Remarks:
(1) Time from firing of line gun to lowering of ramp on deck.
(2) Time from firing of line gun to securing of vessels.
(3) 16 vehicles loaded. 20-ton crane and M15 semitrailer reloaded to Page.
(4) 14 vehicles loaded.
(5) 8 vehicles loaded.
(6) 7 vehicles loaded.
(7) 14 vehicles loaded.
(8) Excessive tie-up time was a result of line handling difficulties.



Resulting Standard Marriage Procedure

Based on the experience gained during the tests, the following procedure has been established for the marriage of the two vessels:

1. The Page approaches the Comet from the most desirable direction; this must be determined from conditions existing at the time. The approach must be made in such a manner that the vessels can be aligned stern to stern and so that the stern of the Page can be maneuvered to within 50 to 75 feet of the Comet.

2. When the Page is in position, a line is fired from the Comet with a shoulder line gun. (This line may be fired from the Page if desired.) The line is attached to two messenger lines which are attached to the Comet's wire-rope warping lines. The warping lines are led from constant-tensioning winches on the Comet's afterdeck through fairleads on her transom.

3. The line fired from the line gun, the messenger lines, and the warping lines are hauled aboard the Page. The warping lines are then secured to pad eyes located on the Page's afterdeck. These pad eyes are located such that they align with the fairleads on the Comet's transom.

4. As soon as the warping lines are secured, the Comet takes in the slack and warps the Page to the Comet's stern using the constant-tensioning feature of the winches. During warping, the Page must be maneuvered laterally as necessary to keep her stern aligned with the Comet.

5. When the Page is warped to the Comet's stern, the mooring pendants are passed from the Comet to the Page. The mooring pendants are secured to the tensioning devices, and hydraulic pressure is applied.

6. The Comet's ramp is then lowered to the Page.

7. The warping lines are released, and the warping lines and messenger lines are returned to the Comet.

To separate the two vessels, the procedure is as follows:

1. The ramp of the Comet is raised.

2. The hydraulic pressure on the tensioning devices is released; this releases the mooring pendants.

3. The mooring pendants are returned to the Comet as the Page gets underway.

Procedure - Discharge of Comet

The Page departed from Fort Eustis, Virginia, and proceeded to Les Sables d'Olonne, France, in order to discharge the Comet in the over-the-shore exercise NODEX 21. The Page arrived at the site approximately 1 week prior to the Comet. Upon arrival of the Page at the site, practice landings were made both at the ramp in the port and at the beach. An M52 tractor with a van* was driven aboard from the ramp, turned around on the vessel, and driven off.

An attempt was made to drive an M52 with an M127 aboard from the beach. As soon as the tractor's front wheels reached the surf, it mired down in the sand and had to be towed out. During the beachings, two waterborne DUKWs were driven aboard the Page and later driven off at the beach.

Prior to the Comet's arrival, 16 M52 truck tractors were driven aboard the Page. The vessel was warped to the bulkhead in the port, and the vehicles were driven directly from the bulkhead to the vessel's deck through the forward side port without the use of a ramp or bridging.

The Comet arrived at Les Sables d'Olonne after a rather severe storm. Although the sea was very rough, the feasibility of making a marriage with the Comet was investigated. The Page made several approaches. Both vessels were pitching heavily, and it was obvious that a marriage under these conditions was impossible. The sea was estimated to be 12 feet high and 600 feet long.

As the Page was departing from the port, the port propeller struck the submerged ground ways of a marine railway. Examination of the propeller, upon return to the port, revealed that the tips of five blades were bent and that the sixth blade was damaged. The vessel was ballasted until the propeller rotor was above the water, and the six damaged blades were replaced with spares.

Upon completion of the propeller repairs, another marriage was attempted. The Page approached the Comet, and warping lines were passed from the Comet and secured to the Page. As the Comet attempted to warp the Page to the Comet's stern, both of the warping lines parted. At the time, the sea

* The vans used were commercial vehicles.

was moderate with an occasional heavy roller and was estimated to be from 6 to 10 feet high and 600 feet long. The vertical motion of the stern of the Comet was about 12 feet. No further attempt was made, as a marriage under these conditions was not considered feasible.

Before another marriage was attempted, both vessels moved to a position in the lee of Ile de Re. At the first position, there was an 18-knot wind with a sea about 4 feet high and 200 feet long. The Comet anchored, and the Page approached from the Comet's bow parallel to and off her starboard side. Warping lines were passed from the Comet and were secured to the Page. Before the Page could be warped into position to receive the mooring lines, the starboard warping line parted. The port side of the Page's stern fender struck the Comet's stern and sheared off one rubber fender, and the corner of the Comet's transom sheared through the Page's stern fender.

All observers were of the opinion that this marriage could have been completed if the warping line had not parted. Rather than risk further damage, both vessels moved to a position where the sea was smooth with a slight chop running. A marriage was completed without difficulty and 1 M127, 15 vans, and 60 M38s were driven from the Comet and stowed on the Page. The 16 M52s previously loaded on the Page were used to pick up the M127 and vans on the Comet and were retained as a unit.

Upon return to Les Sables d'Olonne, the Page made two beachings through surf, estimated to be 6 feet high. On the first beaching, the Page grounded forward in 4 feet of water. After it was decided that the vehicles could not be driven through the surf, the Page retracted and made a second beaching. On the second beaching, the vessel grounded aft, with 6 feet of water at the ramp. After the second beaching, the vessel retracted, proceeded to the port, beached on the ramp, and discharged the vehicles. During the beachings, the vessel was easily controlled and there was no tendency to broach. While at the ramp, 16 M52s were loaded for use in the next marriage.

Another attempt was made to accomplish a marriage in the rough waters off Les Sables d'Olonne. Several approaches were made to evaluate conditions and to ascertain the feasibility of a marriage. The sea was estimated to be 6 feet high and 400 feet long. The vertical motion of the Comet's stern was about 12 feet, and the relative vertical motion between the two vessels was estimated to exceed 25 feet. Upon recommendation of the Comet's master, it was agreed that a marriage should not be attempted. Hence, both vessels proceeded again to a position in the lee of Ile de Re.

Upon the arrival of the vessels off Ile de Re, a marriage was accomplished and 16 M127s, 8 vans, and 52 M38s were driven from the Comet and stowed on the Page. The 16 M52s were used to pick up the M127s and vans on the

Comet and tow them to the Page. Eight of these trailers, after being towed to the Page, were disconnected from the tractors and stowed on the Page; only their landing gear was used.

During the loading of these vehicles, 78 M38s were loaded on LCUs in the following manner:

1. The Page's ramp was lowered.

2. The LCU approached the Page's bow ramp.

3. Head lines were passed and secured to the Page.

4. Position was maintained by backing down on the LCU's engine.

5. The ramp of the LCU was lowered on the Page's ramp.

6. Vehicles were driven aboard the LCU.

Three methods of vehicle transfer were used: a complete load of vehicles was driven from the Comet and assembled on the Page's deck prior to positioning the LCUs; a partial load was assembled on the Page's deck prior to positioning, and the remainder were driven from the Comet during loading; all vehicles were driven directly from the Comet through the Page to the LCUs. All jeeps were loaded from one side of the Page while larger vehicles were being loaded and stowed on the opposite side. Upon completion of the loading, the Page returned to the ramp in the port, discharged the vehicles, and loaded 8 M52s.

The third and final marriage was accomplished in the same area as the second marriage. During the marriage, 11 M127s, 18 vans, and 37 M38s were driven from the Comet to the Page. As in the previous marriage, the M52s were used to tow the M127s and vans from the Comet, and the M127 and vans were then disconnected and stowed on their landing gear. The last eight to be moved remained together as a single unit. Concurrent with the loading of the Page, 49 M38s were loaded on LCUs, using the same procedure as in the previous marriage. After the completion of the loading, the Page again returned to the ramp in the port, and the vehicles were driven off. The trailers that were stowed on their landing gears were picked up on the Page's deck by M52s from the shore.

The Page could enter the port only at high tide and could not remain at the ramp for a period in excess of 2 hours. It was originally planned to make a landing at each high tide. After the move to Ile de Re, this was still possible, although there was an average run of 38 miles each way. As a result of the shifting of the marriage site from Les Sables d'Olonne to Ile de Re and back, and the loading of the LCUs, landings were made on every other tide.

Results

The practice landings prior to the arrival of the Comet and the two beachings demonstrated that the Page could beach under conditions when the vehicles could neither negotiate the surf nor the beach. If heavy vehicles are to be landed, it was demonstrated that a prepared roadway must be used. Any vehicle that is landed on the beach must be capable of fording 4 feet of water in addition to the existing surf.

The ease of maneuverability of the vessel in the restricted and congested area in the port and the control of the vessel during beaching were far in excess of that usually found in vessels of this size and type. Also, it was demonstrated that the vessel has an exceptional beaching and retraction capability.

The damaged propeller and the repairs thereto demonstrated the feasibility of removing the blades of a vertical-axis propeller from within the vessel. Six blades were replaced by the crew without the use of a dry dock, marine railway, or other assistance. The propeller was operational 25-1/2 hours after the work was started.

It was definitely determined that the vessels cannot be married without damage when the relative vertical motion between the two vessels exceeds 4 feet. Hence, the marriage should not be attempted in any sea condition that produces greater motion between the two vessels. Furthermore, the Comet must arrive at destination with a draft aft not exceeding 22 feet. When the sea condition at Les Sables d'Olonne was such as to prohibit a marriage, the operational site was moved approximately 38 miles and a suitable sea state found. In this connection, it should be noted that both the vessels and the cargo are mobile, and there would be few instances when the operational site could not be selected in a sheltered area.

The concepts and techniques developed during the Chesapeake Bay test were proven to be practical, and it was determined that the Comet can be discharged at sea. An operational summary is given in Table 34, and a cargo summary in Table 35. A summary of the LCU loadings is given in Table 36.

TABLE 34
OPERATIONAL SUMMARY OF DISCHARGE OF COMET

Run	At Comet: Tie-Up Time (min.)	At Comet: Total Marriage Time (hr.)	At Comet: Sea Condition Height (ft.)	At Comet: Sea Condition Length (ft.)	At Comet: Wind Vel. (k.)	At Ramp: On Ramp (hr.)	At Ramp: Time Unload (min.)	At Ramp: Time Load (min.)	Remarks
0	-	-	-	-	-	-	-	6.5	16 M52 tractors loaded from bulkhead.
1	-	-	12	600	20	-	-	-	Both warping lines parted; moved to sheltered area.
2	-	-	4	200	18	-	-	-	Stbd. warping line parted; moved to more sheltered area.
3	9.25	3.56	0	0	7-9	0.93	45.42	2.00	Stern of Page collided with after quarter of Comet.
4	6.90	6.94	0	0	0-10	0.69	31.75	1.63	Loaded 3 LCU's off ramp. This run designated as 4A.
5	5.63	9.15	2	150	10-12	1.45	90.40	-	Stbd. warping line parted; loaded 2 LCU's off ramp. This run designated as 5A.

TABLE 35
CARGO SUMMARY OF LOADING OPERATIONS DURING DISCHARGE OF COMET

Run	Vehicles Loaded at Comet No.	Vehicles Loaded at Comet Type	Vehicles Unloaded at Ramp No.	Vehicles Unloaded at Ramp Type	Vehicles Loaded at Ramp No.	Vehicles Loaded at Ramp Type	Total Vehicles On Page	Weight Tons (2,240 lb. to the ton)	Measurement Tons (40 cu. ft. to the ton)	Remarks
0	-	-	-	-	16	M52	16	130	480	Used for loading at Comet.
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	1	M127	1	M127	-	-	-	16	52	The 16 M52s loaded on run 0 picked up 1 M127 and 15 vans from the Comet. 16 M52s were loaded for run 4.
	15	van	15	van	-	-	-	240	780	
	60	M38	60	M38	16	M52	76	60	420	
4	16	M129	16	M127	-	-	-	256	832	The 16 M52s loaded on run 3 picked up 16 M127s from the Comet. 8 vans loaded from the Comet were picked up by M52s at the ramp of the Page. 8 M52s were loaded on the Page.
	8	van	8	van	-	-	-	128	416	
	52	M38	52	M38	8	M52	76	52	364	
4A	78	M38	-	-	-	-	-	78	546	Loaded to LCUs
5	11	M127	11	M127	-	-	-	176	572	The M52s loaded on run 4 picked up 8 vans from the Comet. 11 M127s and 10 vans loaded from the Comet were picked up by M52s at the ramp of the Page.
	18	van	18	van	-	-	-	288	936	
	37	M38	37	M38	-	-	66	37	259	
5A	49	M38	-	-	-	-	-	49	343	Loaded to LCUs.

TABLE 36
SUMMARY OF LCU LOADINGS DURING DISCHARGE OF COMET

Run	Craft	Jeeps (no.)	Weight Tons (2,240 lb. to the ton)	Measurement Tons (40 cu. ft. to the ton)	Loading Time (min.)	Remarks
4A	LCU 1545	26	26	182	23.00	Part load assembled on Page's deck. Drivers returned to Comet for remainder.
	LCU 1582	26	26	182	18.00	Vehicles assembled on Page's deck.
	LCU 1576	26	26	182	17.00	Vehicles assembled on Page's deck.
5A	LCU 1545	26	26	182	46.33	Drivers returned to Comet for vehicles.
	LCU 1576	23	23	161	17.15	Vehicles assembled on Page's deck.

DETERMINATION EIGHT. Performance of Propellers Fitted With Sinusoidal and Rotor "A" Blade Linkage

Procedure

Prior to the removal of the sinusoidal linkage from the propellers, David Taylor Model Basin torsionmeters and instrumentation were installed, and standardization trials were conducted on the course off Kent Island, Maryland. The trials consisted of runs over the course at pitch settings of 0.4π, 0.5π, 0.55π, 0.6π, and 0.65π. Each point on the curve was determined by three runs over the course. Only three points were run at 0.4π because of the low vessel speed. Four points were run at 0.6π and three points at 0.65π because the upper limit of engine output was approached. Whenever runs were questionable, they were rerun to confirm the data previously obtained.

The blade angle for the starboard propeller with sinusoidal linkage at 0.65π pitch was taken by the propeller manufacturer prior to shipment (Figure 17). After the trials, the control stick indicator position and maximum blade angle were calibrated for both propellers (Figures 18 and 19).

BLADE-ANGLE DATA

BLADE NO.	ROTOR ROTATION (DEG.)												
	0	30	60	90	120	150	180	210	240	270	300	330	360
M	1*	19	32	35	28	13	-6	-25	-41	-45	-36	-19	0*
1	-1	17	30/30*	34	26	13	-7	-27	-42	-46	-37	-21	-1
2	0	18	31	35	28/28*	13	-5	-26	-42	-45	-35	-19	0
3	1	19	31	35	28	14	-5/-6*	-25	-41	-46	-37	-19	1
4	1	20	33	36	28	14	-4	-24	-40/-40*	-45	-35	-17	1
5	-1	17	30	34	26	12	-7	-26	-43	-47	-38/-37*	-20	-1

*BLADE PASSED POSITION TWICE

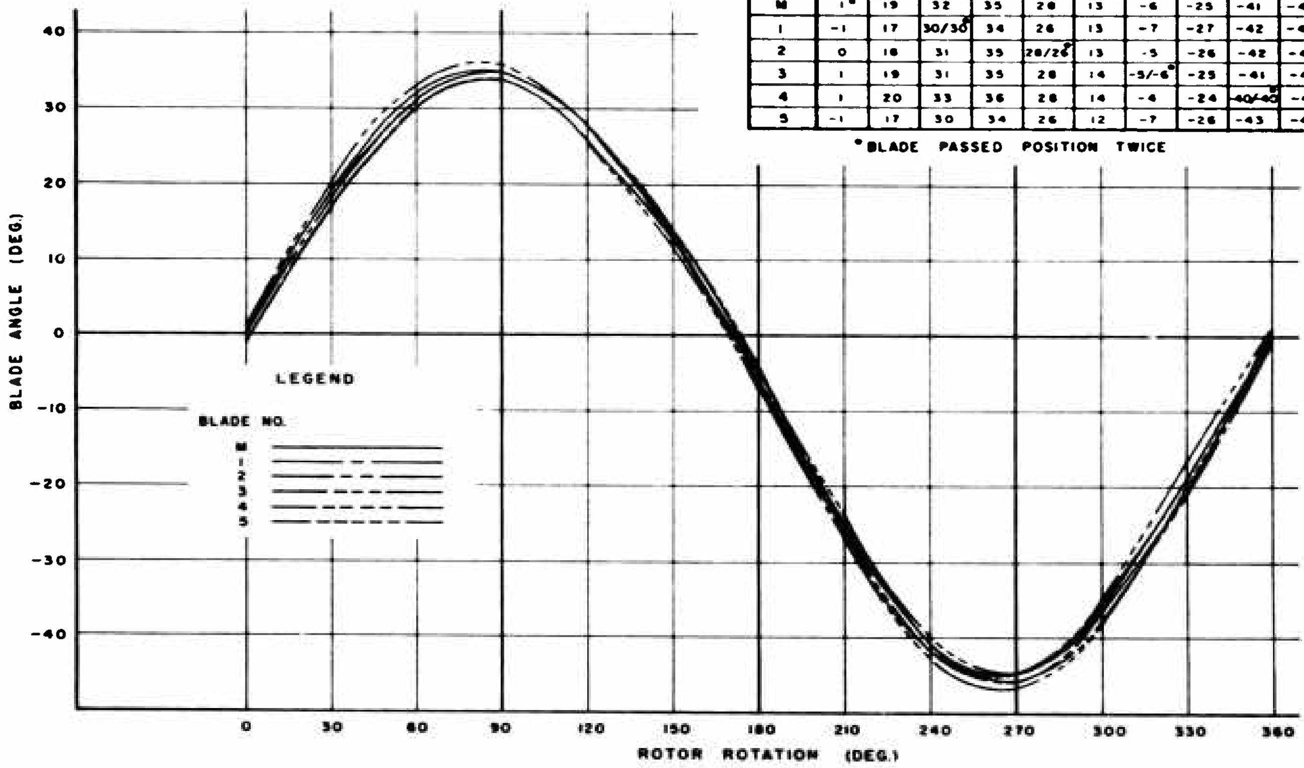


Figure 17. Starboard Propeller Blade Angles at 0.65π Pitch (Sinusoidal Linkage).

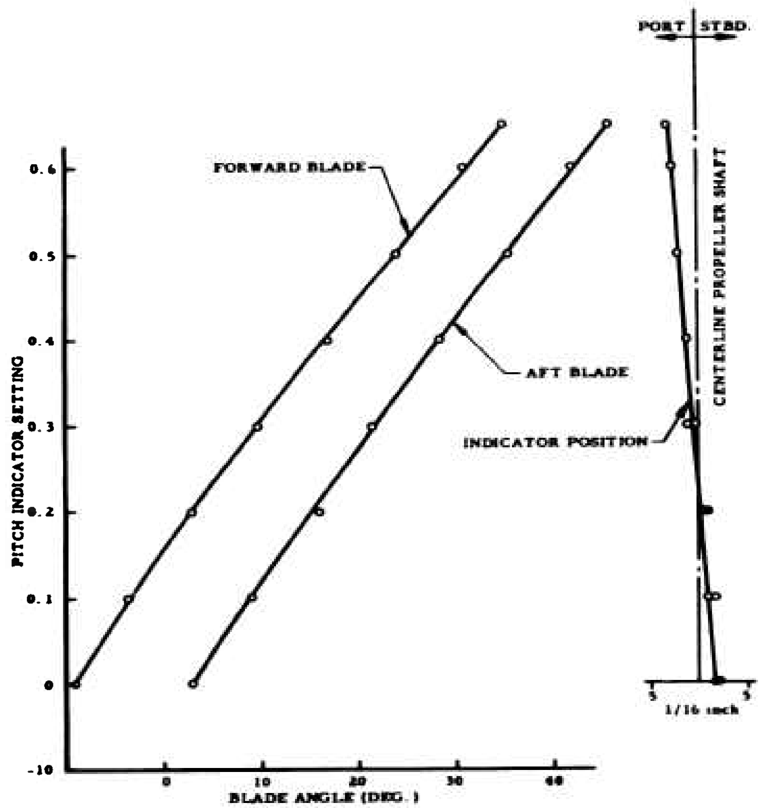


Figure 18. Blade-Angle Calibration, Starboard Propeller (Sinusoidal Linkage).

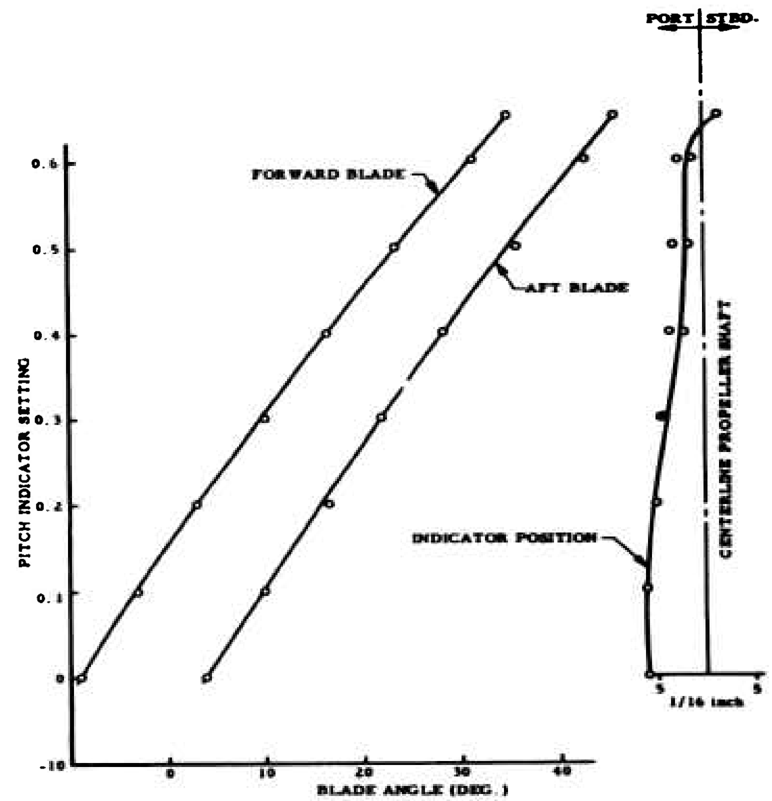


Figure 19. Blade-Angle Calibration, Port Propeller (Sinusoidal Linkage).

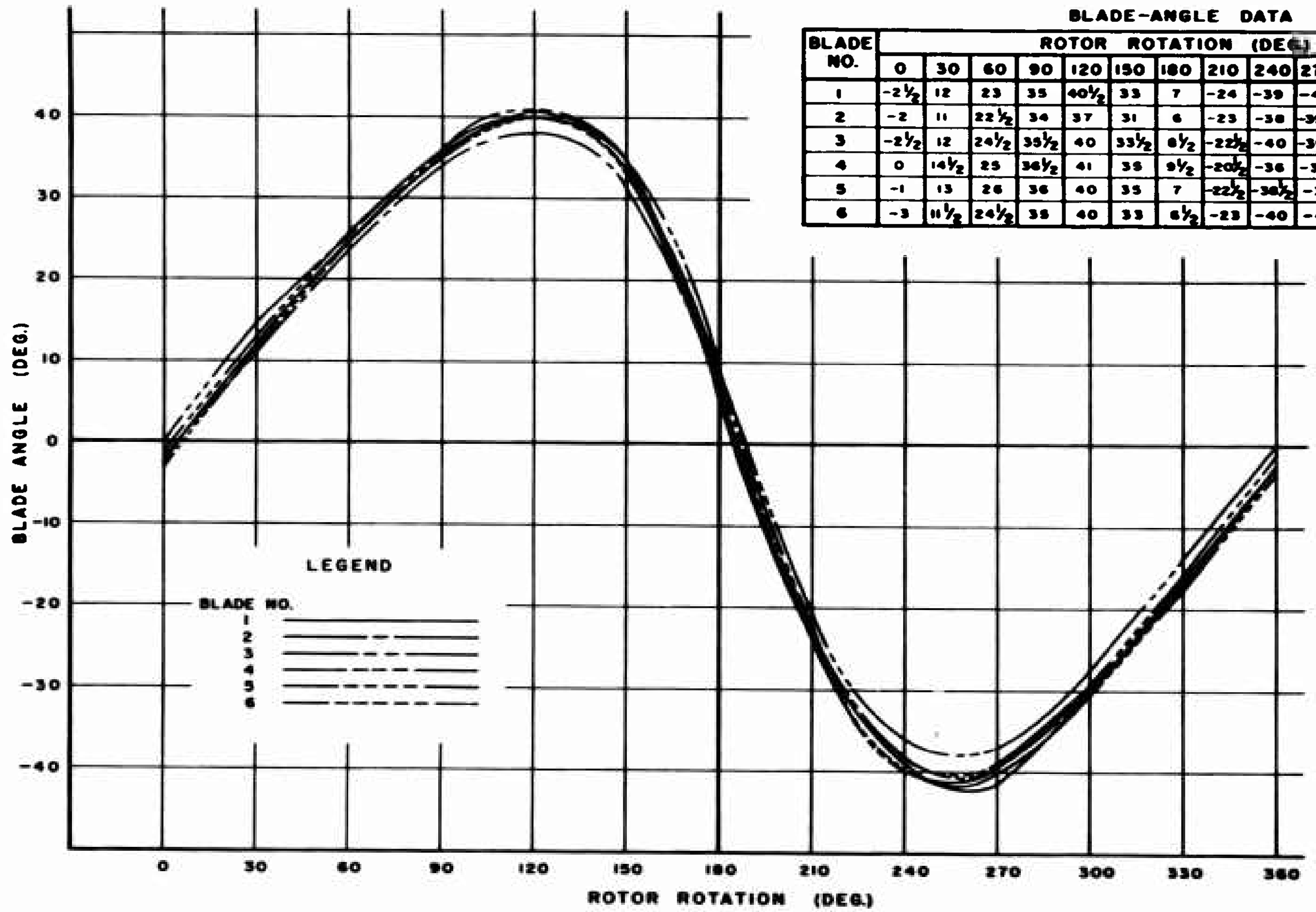
Upon completion of the trials, the sinusoidal linkage was removed, and the Rotor "A" linkage was installed. Upon installation of the Rotor "A" linkage, difficulty was encountered in the control of both the steering and the pitch. To correct this condition, the oil pressure in the hydraulic control system was increased from 500 psig to 1,000 psig. This had very little effect on the control system. The hydraulic cylinders, along with their servo-valves, pneudynes, and linkage, were rotated 34 degrees in the direction opposite to the propeller rotation. Also, the pitch pneudyne stroke was increased from 2-21/32 inches to 4 inches. This modification permitted control of pitch and improved steering to the extent that the vessel could be operated at full power. However, a one-revolution oscillation of the control stick developed. Attempts to determine the source of the force, or forces, which caused this oscillation were unsuccessful (Reference 3).

David Taylor Model Basin torsionmeters and instrumentation were again installed, and standardization trials were conducted on the Kent Island course. Insofar as practical, these trials duplicated those conducted with the sinusoidal linkage. During both trials, the vessel was ballasted to landing displacement. The average calculative drafts during the trials were as given in Table 37.

TABLE 37
AVERAGE CALCULATIVE DRAFTS DURING
STANDARDIZATION TRIALS

Linkage	Forward	Amidships	Aft
Sinusoidal	9' 6-1/2"	10' 1-1/2"	11' 0"
Rotor "A"	10' 1-1/2"	10' 5"	10' 1/2"

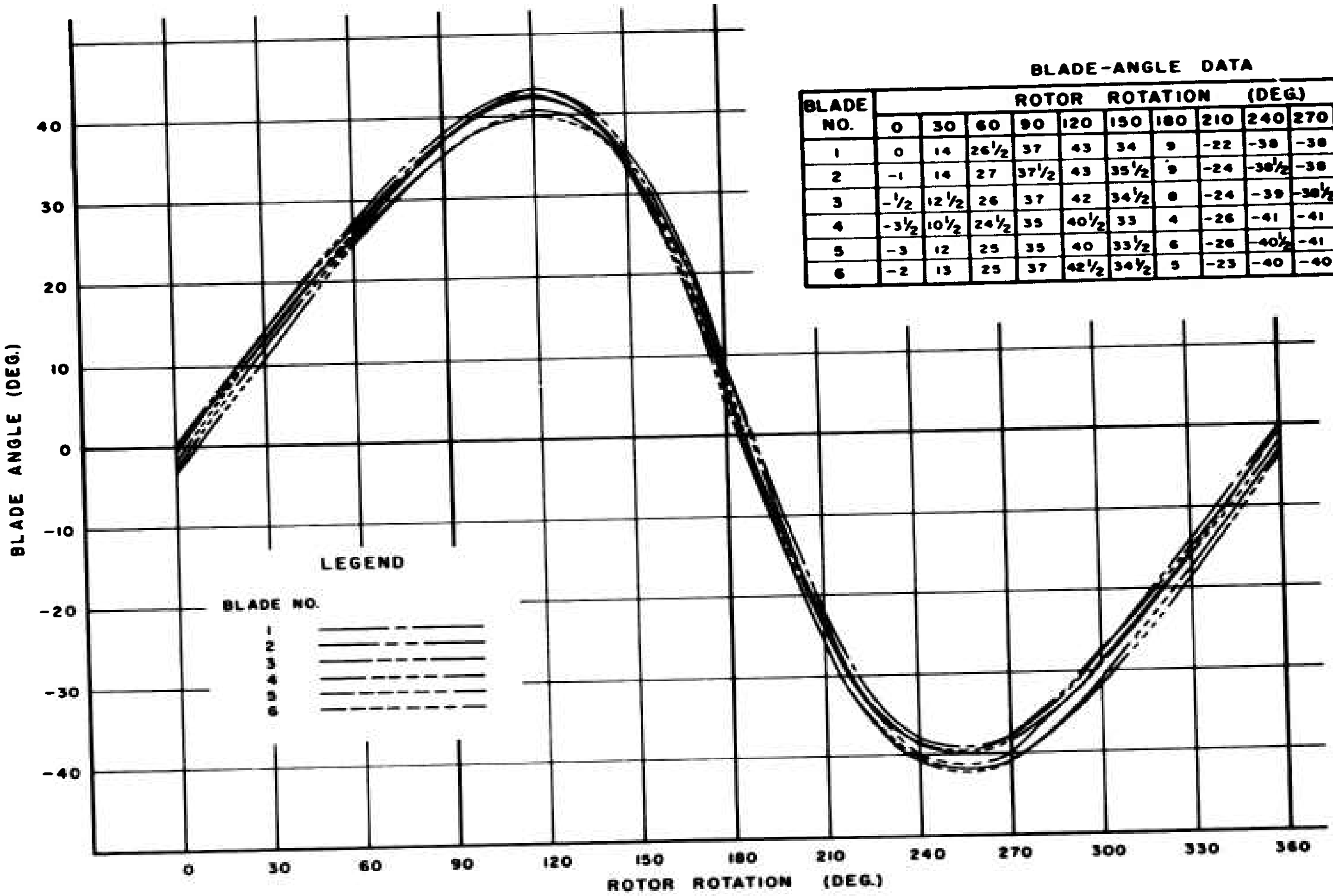
After the trials, the blade angles for 0.65π pitch were measured for both propellers (Figures 20 and 21). During the measurement of the blade angles, it was noted that the blades did not follow in the same path. Hence, blade angles were measured for two revolutions for each of the blades on the starboard propeller (Figures 22 through 27). At the same time, the control stick pointer positions and the maximum blade angles were correlated (Figure 28).



BLADE-ANGLE DATA

BLADE NO.	ROTOR ROTATION (DEG.)												
	0	30	60	90	120	150	180	210	240	270	300	330	360
1	-2½	12	23	35	40½	33	7	-24	-39	-40	-30	-16½	-2½
2	-2	11	22½	34	37	31	6	-23	-38	-39½	-30	-17	-2
3	-2½	12	24½	35½	40	33½	8½	-22½	-40	-38½	-29½	-16½	-2½
4	0	14½	25	36½	41	35	9½	-20½	-36	-37	-27½	-13½	0
5	-1	13	26	36	40	35	7	-22½	-38½	-39	-29½	-18½	-1
6	-3	11½	24½	35	40	33	6½	-23	-40	-40	-30½	-18	-3

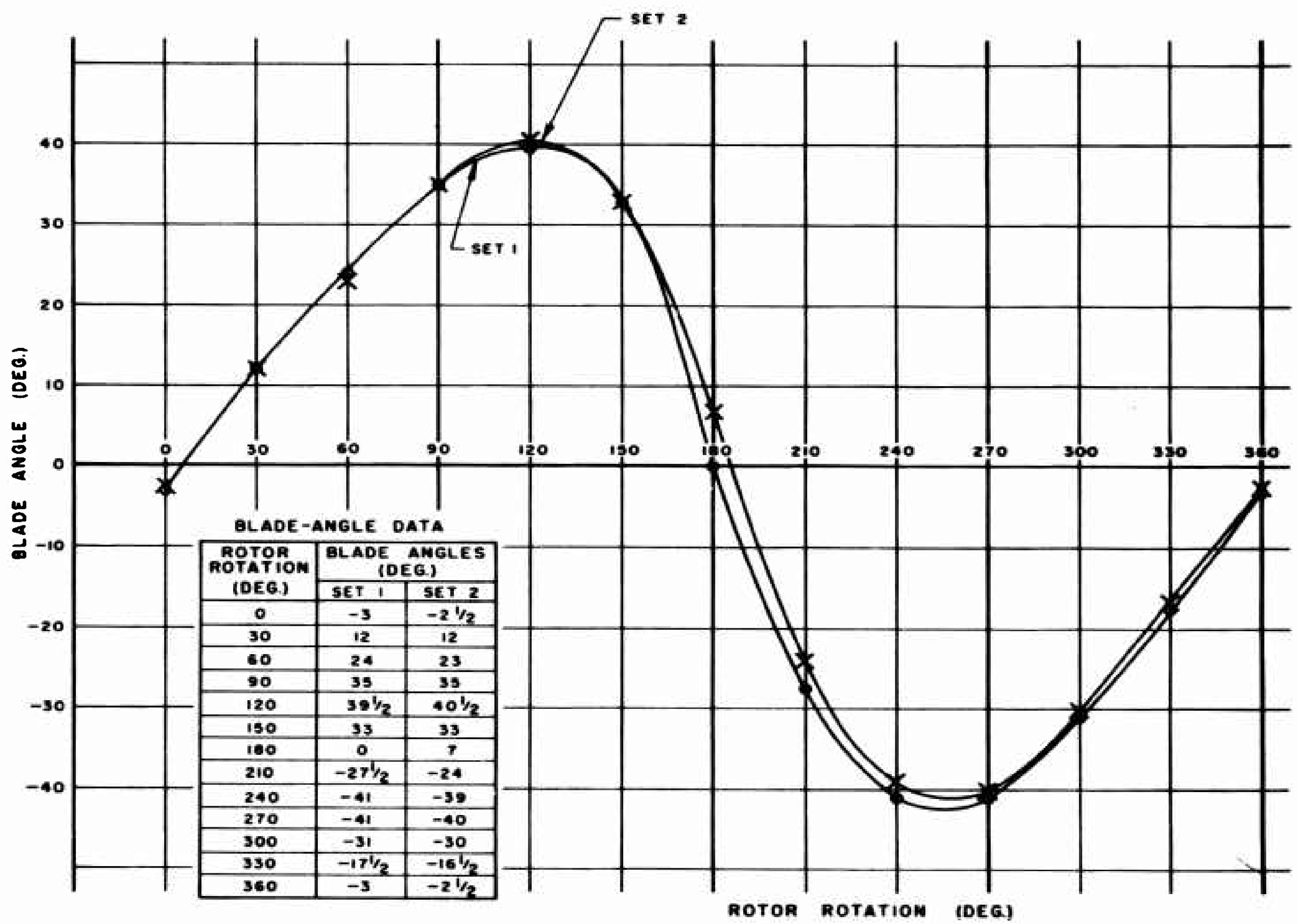
Figure 20. Starboard Propeller Blade Angles at 0.65π Pitch (Rotor "A" Linkage).



BLADE-ANGLE DATA

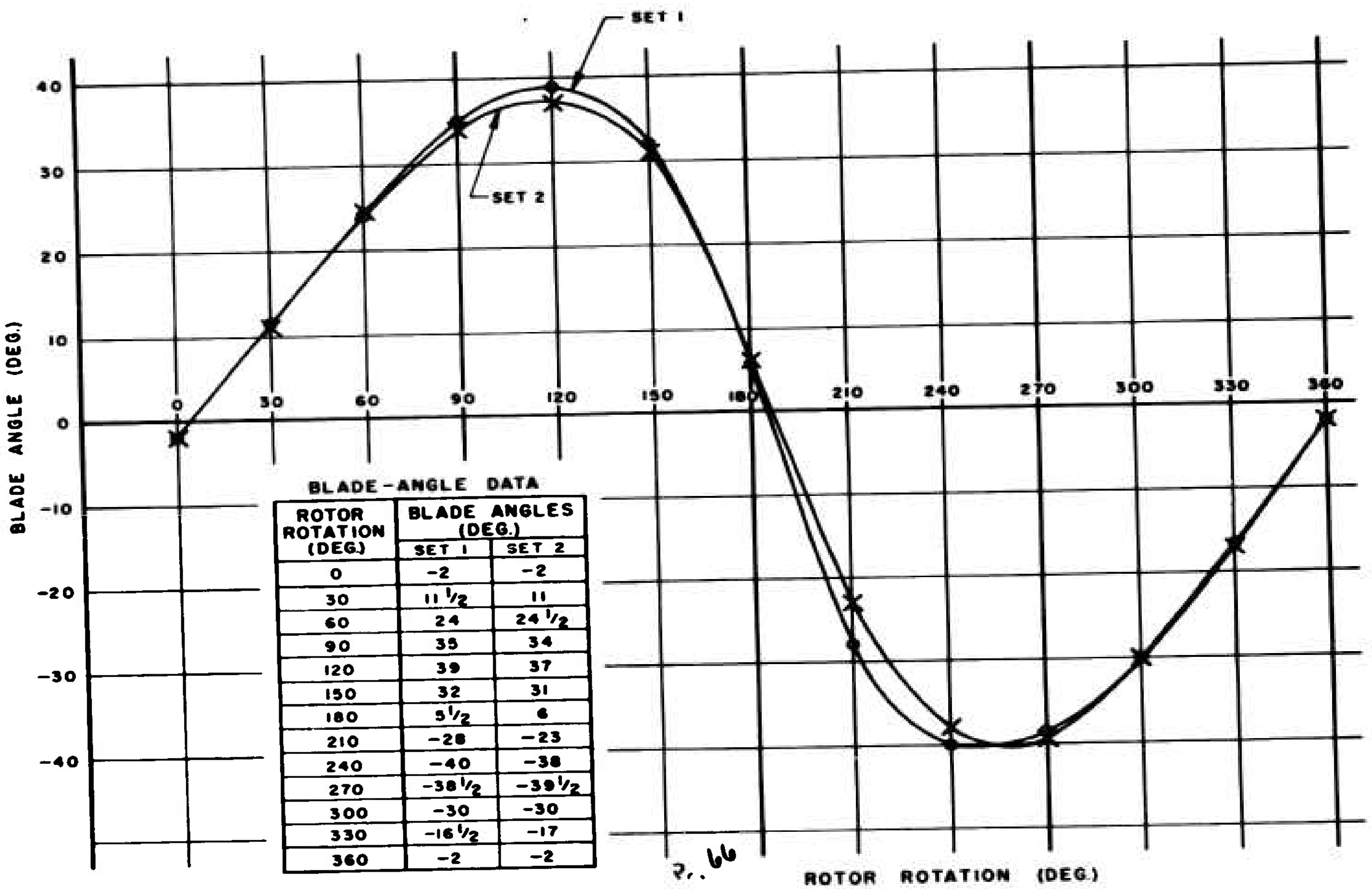
BLADE NO.	ROTOR ROTATION (DEG.)												
	0	30	60	90	120	150	180	210	240	270	300	330	360
1	0	14	26½	37	43	34	9	-22	-38	-38	-28	-14	0
2	-1	14	27	37½	43	35½	9	-24	-38½	-38	-27½	-15	-1
3	-½	12½	26	37	42	34½	8	-24	-39	-38½	-29	-15½	-½
4	-3½	10½	24½	35	40½	33	4	-26	-41	-41	-31½	-18½	-3½
5	-3	12	25	35	40	33½	6	-26	-40½	-41	-31	-17½	-3
6	-2	13	25	37	42½	34½	5	-23	-40	-40	-29	-18½	-2

Figure 21. Port Propeller Blade Angles at 0.65π Pitch (Rotor "A" Linkage).



ROTOR ROTATION (DEG.)	BLADE ANGLES (DEG.)	
	SET 1	SET 2
0	-3	-2 1/2
30	12	12
60	24	23
90	35	35
120	39 1/2	40 1/2
150	33	33
180	0	7
210	-27 1/2	-24
240	-41	-39
270	-41	-40
300	-31	-30
330	-17 1/2	-16 1/2
360	-3	-2 1/2

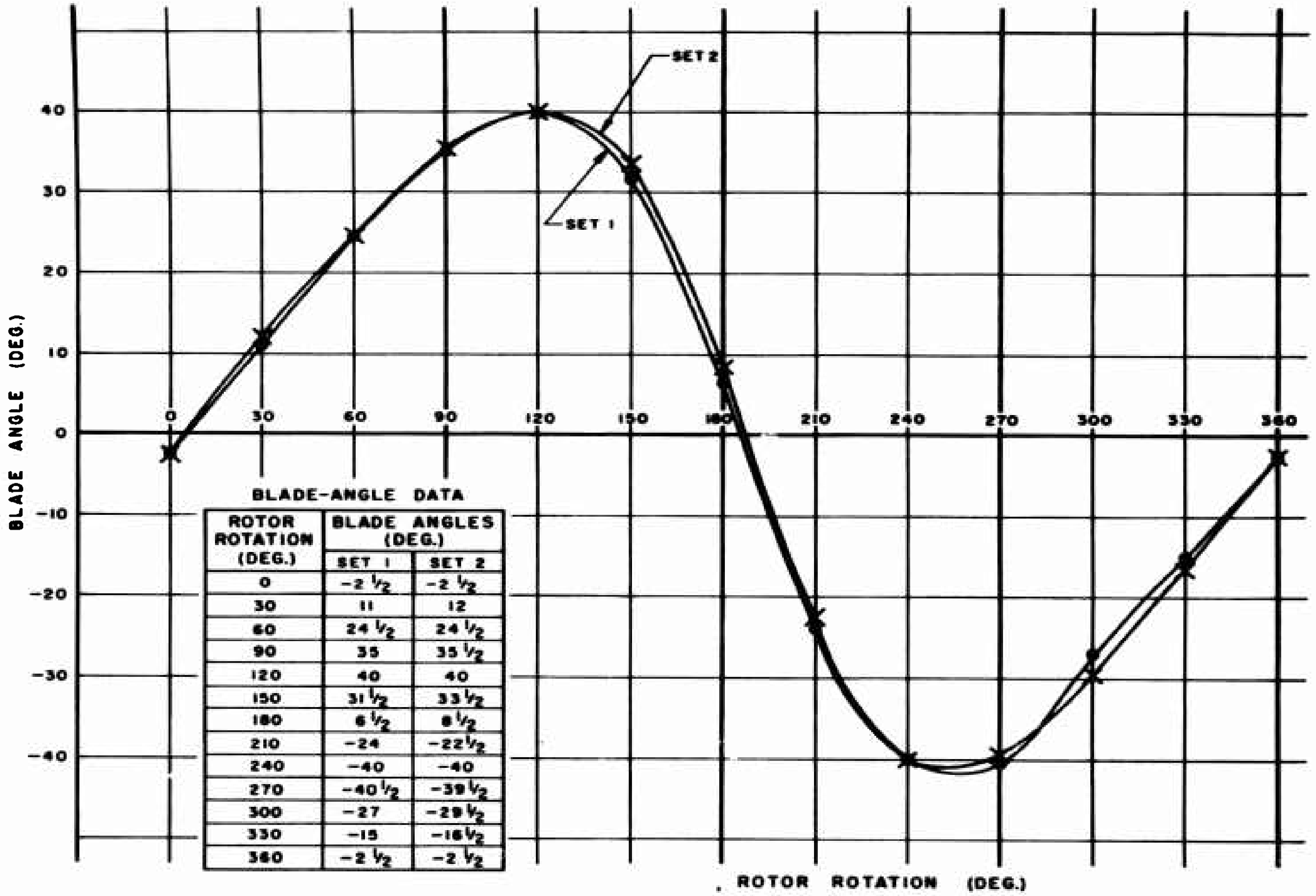
Figure 22. Angles of Starboard Propeller Blade 1 at 0.65π Pitch (Rotor "A" Linkage).



BLADE-ANGLE DATA

ROTOR ROTATION (DEG.)	BLADE ANGLES (DEG.) SET 1	BLADE ANGLES (DEG.) SET 2
0	-2	-2
30	11 1/2	11
60	24	24 1/2
90	35	34
120	39	37
150	32	31
180	5 1/2	6
210	-28	-23
240	-40	-38
270	-38 1/2	-39 1/2
300	-30	-30
330	-16 1/2	-17
360	-2	-2

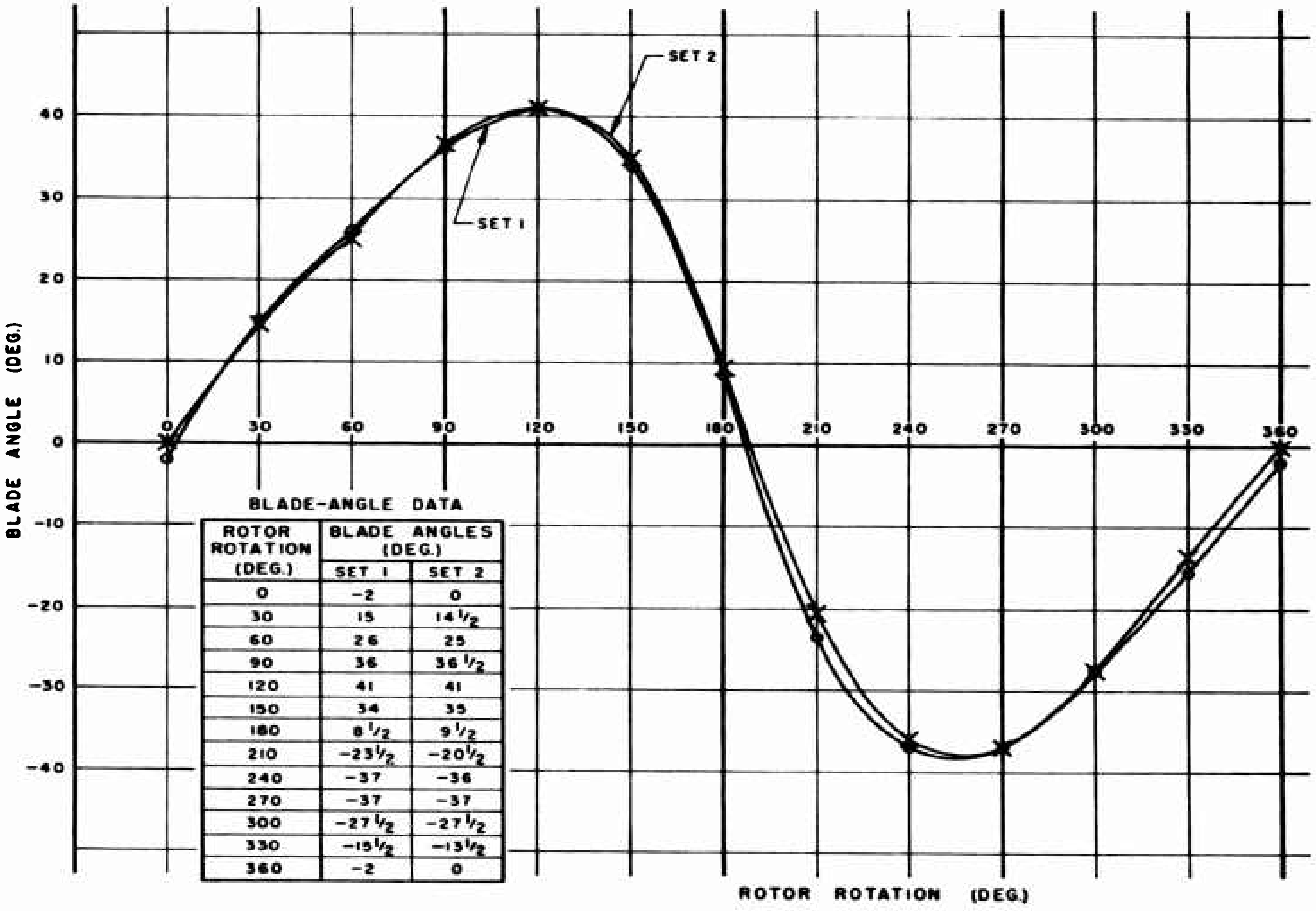
Figure 23. Angles of Starboard Propeller Blade 2 at 0.65π Pitch (Rotor "A" Linkage).



BLADE-ANGLE DATA

ROTOR ROTATION (DEG.)	BLADE ANGLES (DEG.)	
	SET 1	SET 2
0	-2 1/2	-2 1/2
30	11	12
60	24 1/2	24 1/2
90	35	35 1/2
120	40	40
150	31 1/2	33 1/2
180	6 1/2	8 1/2
210	-24	-22 1/2
240	-40	-40
270	-40 1/2	-39 1/2
300	-27	-29 1/2
330	-15	-16 1/2
360	-2 1/2	-2 1/2

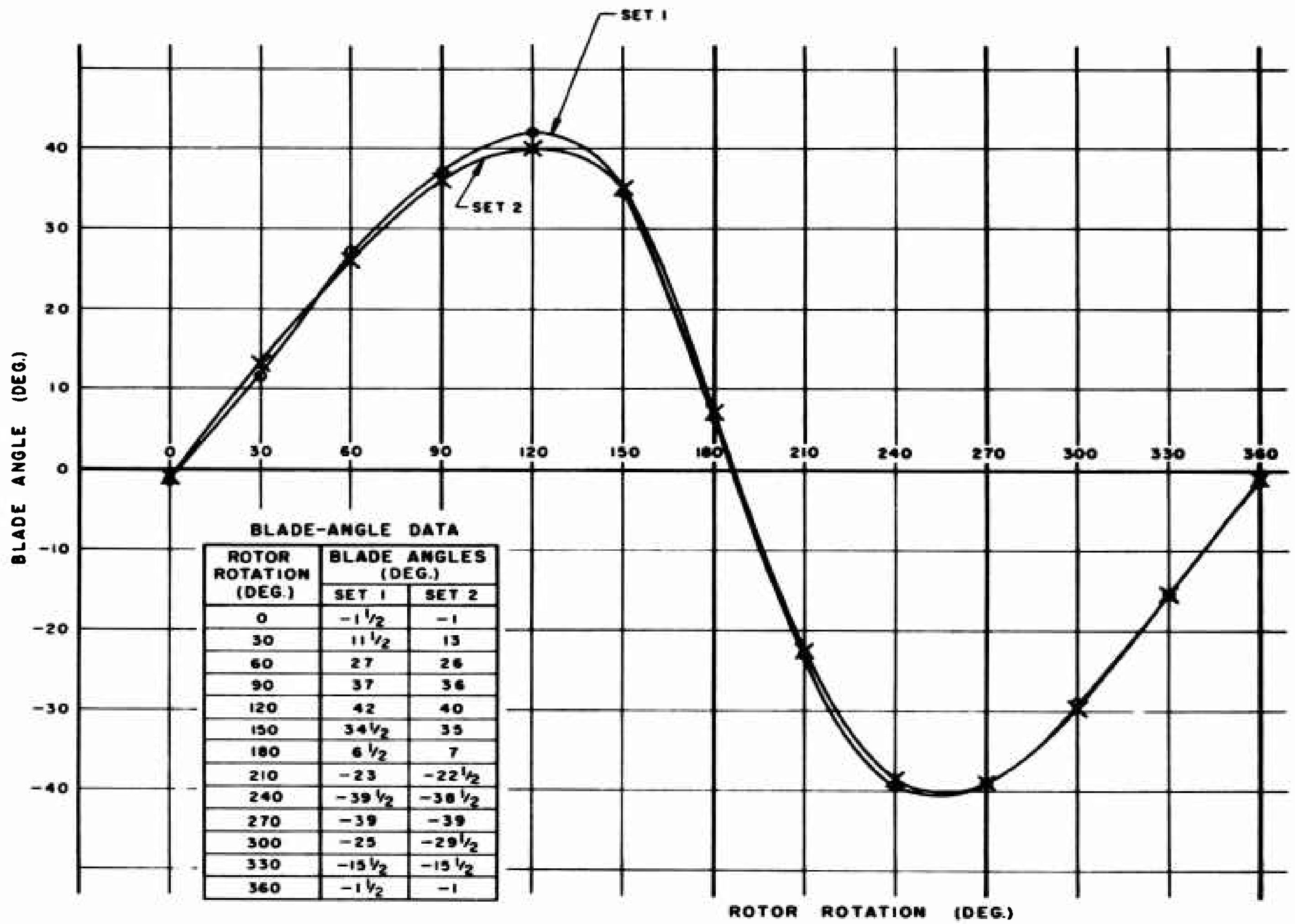
Figure 24. Angles of Starboard Propeller Blade 3 at 0.65π Pitch (Rotor "A" Linkage).



BLADE-ANGLE DATA

ROTOR ROTATION (DEG.)	BLADE ANGLES (DEG.)	
	SET 1	SET 2
0	-2	0
30	15	14 1/2
60	26	25
90	36	36 1/2
120	41	41
150	34	35
180	8 1/2	9 1/2
210	-23 1/2	-20 1/2
240	-37	-36
270	-37	-37
300	-27 1/2	-27 1/2
330	-15 1/2	-13 1/2
360	-2	0

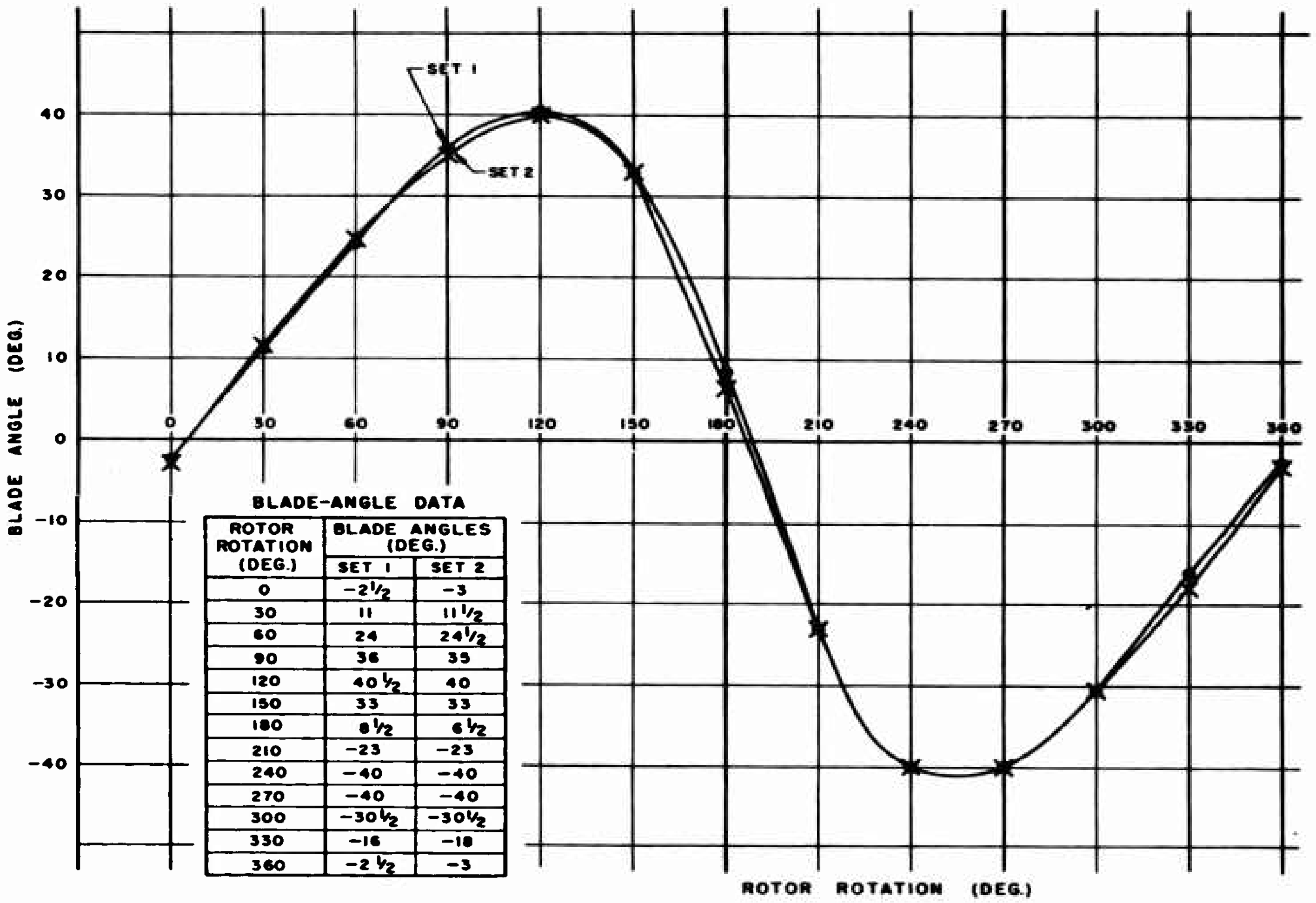
Figure 25. Angles of Starboard Propeller Blade 4 at 0.65π Pitch (Rotor "A" Linkage).



BLADE-ANGLE DATA

ROTOR ROTATION (DEG.)	BLADE ANGLES (DEG.) SET 1	BLADE ANGLES (DEG.) SET 2
0	-1 1/2	-1
30	11 1/2	13
60	27	26
90	37	36
120	42	40
150	34 1/2	35
180	6 1/2	7
210	-23	-22 1/2
240	-39 1/2	-38 1/2
270	-39	-39
300	-25	-29 1/2
330	-15 1/2	-15 1/2
360	-1 1/2	-1

Figure 26. Angles of Starboard Propeller Blade 5 at 0.65π Pitch (Rotor "A" Linkage).



BLADE-ANGLE DATA

ROTOR ROTATION (DEG.)	BLADE ANGLES (DEG.)	
	SET 1	SET 2
0	-2½	-3
30	11	11½
60	24	24½
90	36	35
120	40½	40
150	33	33
180	8½	6½
210	-23	-23
240	-40	-40
270	-40	-40
300	-30½	-30½
330	-16	-18
360	-2½	-3

Figure 27. Angles of Starboard Propeller Blade 6 at 0.65π Pitch (Rotor "A" Linkage).

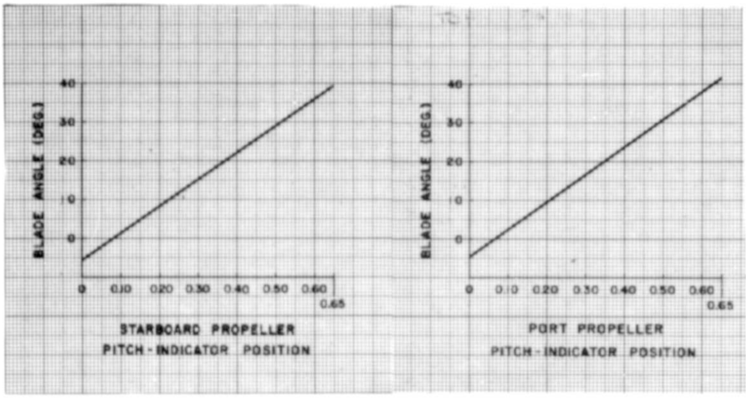


Figure 28. Blade-Angle Calibration, Port and Starboard Propeller (Rotor "A" Linkage).

The propeller manufacturer conducted a spin test of the propeller and determined the horsepower necessary to rotate the propeller in air. During the standardization trials, the propellers were operated at five different speeds at zero pitch, and the horsepower was determined for each speed. This no-load test was conducted for both the sinusoidal and the Rotor "A" linkage.

Results

The sinusoidal linkage at maximum rpm and 0.60π or 0.65π pitch was found to overload the engines. With the Rotor "A" linkage, the engines could not be overloaded. However, at maximum rpm and 0.65π, the pitch control was so erratic that satisfactory data could not be obtained.

Considerable vibration was experienced with the sinusoidal linkage with pitches in excess of 0.55π and engine rpm in excess of 750. The intensity of the vibration increased with both the pitch and the engine rpm. With the Rotor "A" linkage, vibration was reduced to the extent that at full power it was well below the acceptable limits.

The maximum speed with the sinusoidal linkage was 9.5 knots. This speed was obtained at 0.65π pitch and an average of 67.74 propeller rpm and required 2,225 horsepower. With the Rotor "A" linkage, the maximum speed was 10.08 knots. This was obtained at 0.60π pitch and an average of 74.95 propeller rpm, and it required 1,794 horsepower. At 0.65π pitch and 67.74 rpm, a speed of 10.03 knots was obtained, and this required 1,696 horsepower. Test results are tabulated in Tables 38 and 39.

TABLE 38

STANDARDIZATION TRIALS: PROPELLERS FITTED WITH SINUSOIDAL LINKAGE U

Run and Dir.	Pitch Setting	Starboard Propeller: Blade Angle (deg.)	Pitch (ft.)	RPM	SHP	Eng Rack (mm.)	Exh. Temp. (° F)	Port Propeller: Blade Angle (deg.)	Pitch (ft.)	RPM	SHP	Eng. Rack (mm.)	Exh. Temp. (° F)
2-N	0.40	16.7	8.423	79.03	495.54	4.00	495	16.5	8.325	78.71	469.85	3.8	519
3-S	0.40	16.7	8.423	79.05	488.48	4.00	493	16.5	8.325	78.25	443.89	3.5	509
4-N	0.40	16.7	8.423	79.04	485.53	4.00	499	16.5	8.325	78.45	441.90	3.9	51[illegible]
Average	-	-	-	79.04	489.51	4.00	495	-	-	78.41	449.88	3.6	514
9-S	0.40	16.7	8.423	75.83	418.24	3.50	462	16.5	8.325	78.82	489.61	4.1	533
10-N	0.40	16.7	8.423	75.82	410.97	3.50	465	16.5	8.325	76.57	478.25	3.9	505
Average	-	-	-	75.82	414.60	3.50	463	-	-	77.69	483.93	4.0	519
18-N	0.40	16.7	8.423	69.97	317.08	3.00	419	16.5	8.325	69.07	344.86	3.0	551
19-S	0.40	16.7	8.423	69.87	330.36	3.10	428	16.5	8.325	69.13	297.06	3.0	422
Average	-	-	-	69.92	323.72	3.05	423	-	-	69.10	320.96	3.0	486
37-S	0.40	16.7	8.423	62.34	236.41	3.00	380	16.5	8.325	59.90	184.39	2.5	342
38-N	0.40	16.7	8.423	62.53	221.01	3.00	375	16.5	8.325	59.77	206.21	2.5	359
Average	-	-	-	62.43	228.71	3.00	377	-	-	59.83	195.30	2.5	350
39-S	0.40	16.7	8.423	63.38	266.16	3.00	404	16.5	8.325	63.70	232.49	2.5	377
40-N	0.40	16.7	8.423	63.64	235.30	3.00	379	16.5	8.325	63.45	259.56	2.9	385
41-S	0.40	16.7	8.423	63.31	261.15	3.00	385	16.5	8.325	63.73	227.33	2.5	366
Average	-	-	-	63.49	249.47	3.00	387	-	-	63.58	244.73	2.7	378
80-N	0.40	16.7	8.423	63.44	222.07	3.00	370	16.5	8.325	63.08	238.04	2.5	383
81-S	0.40	16.7	8.423	63.35	235.52	3.00	380	16.5	8.325	63.01	242.54	3.0	386
82-N	0.40	16.7	8.423	63.41	222.40	3.00	370	16.5	8.32[illegible]	61.62	231.26	2.5	382
Average	-	-	-	63.39	228.88	3.00	375	-	-	62.68	238.59	2.7	384
7-S	0.50	23.9	11.87	77.52	752.05	5.40	598	23.9	11.87	78.09	878.13	5.8	635
8-N	0.50	23.9	11.87	77.81	741.66	5.00	590	23.9	11.87	79.16	914.12	6.0	692
Average	-	-	-	77.66	746.85	5.20	594	-	-	78.62	896.12	5.9	647
12-N	0.50	23.9	11.87	73.96	610.08	5.00	523	23.9	11.87	73.15	695.63	5.1	622
13-S	0.50	23.9	11.87	73.84	625.15	5.00	555	23.9	11.87	73.36	666.87	4.9	610
14-N	0.50	23.9	11.87	75.14	663.69	5.10	568	23.9	11.87	73.07	719.10	5.1	623
Average	-	-	-	74.19	631.02	5.00	550	-	-	73.23	687.12	5.0	616
24-N	0.50	23.9	11.87	70.13	551.38	4.50	510	23.9	11.87	69.74	607.98	4.4	570
25-S	0.50	23.9	11.87	70.08	540.11	4.50	515	23.9	11.87	70.08	552.61	4.5	560
Average	-	-	-	70.10	545.74	4.50	512	-	-	69.91	580.29	4.5	565
44-N	0.50	23.9	11.87	63.56	386.32	3.50	445	23.9	11.87	63.71	443.15	4.0	493
45-S	0.50	23.9	11.87	64.42	397.26	3.50	446	23.9	11.87	64.90	421.00	3.5	481
46-N	0.50	23.9	11.87	63.56	385.88	3.50	445	23.9	11.87	63.74	444.67	4.0	499
Average	-	-	-	63.99	391.68	3.50	445	-	-	64.31	432.45	3.7	488
56-N	0.50	23.9	11.87	54.42	221.90	3.00	356	23.9	11.87	54.80	251.72	3.0	361
57-S	0.50	23.9	11.87	54.38	229.84	3.00	353	23.9	11.87	54.95	239.52	3.0	359
58-N	0.50	23.9	11.87	54.48	221.03	3.00	359	23.9	11.87	54.85	253.42	3.1	363
Average	-	-	-	54.41	225.65	3.00	355	-	-	54.89	246.04	3.0	360
15-S	0.55	27.5	13.53	76.44	1002.38	6.80	719	27.5	13.53	75.98	1012.94	6.7	750
16-N	0.55	27.5	13.53	76.31	968.58	6.50	700	27.5	13.53	74.69	957.74	6.5	715
17-S	0.55	27.5	13.53	76.19	994.51	6.50	713	27.5	13.53	74.69	963.91	6.4	711
Average	-	-	-	76.31	983.51	6.60	708	-	-	75.01	973.08	6.5	723
28-N	0.55	27.5	13.53	71.41	740.25	5.50	617	27.5	13.53	71.62	813.24	5.5	662
29-S	0.55	27.5	13.53	71.95	810.23	6.00	654	27.5	13.53	71.51	821.45	5.5	665
Average	-	-	-	71.68	775.24	5.70	635	-	-	71.56	817.34	5.5	663
47-S	0.55	27.5	13.53	64.64	559.97	4.60	526	27.5	13.53	63.21	507.97	4.2	536
48-N	0.55	27.5	13.53	63.06	488.57	4.50	510	27.5	13.53	61.48	523.25	4.5	550
49-S	0.55	27.5	13.53	62.98	502.00	-	-	27.5	13.53	63.58	519.31	-	-
Average	-	-	-	63.43	509.78	4.50	518	-	-	62.44	518.44	4.3	543
59-S	0.55	27.5	13.53	53.75	294.25	3.50	406	27.5	13.53	54.25	310.10	3.0	401
60-N	0.55	27.5	13.53	53.81	288.36	3.50	406	27.5	13.53	54.17	323.40	3.2	414
61-S	0.55	27.5	13.53	53.72	300.29	3.50	414	27.5	13.53	54.27	311.30	3.0	409
Average	-	-	-	53.77	292.81	3.50	408	-	-	54.21	317.05	3.1	409
71-S	0.55	27.5	13.53	45.86	191.65	3.00	363	27.5	13.53	45.76	197.58	3.0	367
72-N	0.55	27.5	13.53	46.14	180.59	3.00	342	27.5	13.53	45.82	193.41	3.0	360
73-S	0.55	27.5	13.53	45.92	184.41	3.00	357	27.5	13.53	45.83	193.47	3.0	359
Average	-	-	-	46.01	184.31	3.00	351	-	-	45.81	194.47	3.0	361
30-N	0.60	31.0	15.10	71.24	1019.25	7.10	758	31.2	15.18	70.13	987.10	7.0	768
31-S	0.60	31.0	15.10	70.22	1014.11	7.20	748	31.2	15.18	69.75	983.26	7.0	763
32-N	0.60	31.0	15.10	70.29	985.58	7.10	736	31.2	15.18	69.85	967.37	6.8	750
Average	-	-	-	70.49	1008.26	7.10	747	-	-	69.87	980.25	6.9	761
50-N	0.60	31.0	15.10	62.00	595.53	5.00	562	31.2	15.18	62.13	694.78	5.4	613
51-S	0.60	31.0	15.10	61.97	591.05	5.00	560	31.2	15.18	62.24	681.50	5.5	604
52-N	0.60	31.0	15.10	62.05	587.25	5.00	558	31.2	15.18	62.16	689.97	5.5	611
Average	-	-	-	62.00	591.22	5.00	560	-	-	62.19	686.94	5.5	608
62-N	0.60	31.0	15.10	54.73	405.44	4.00	469	31.2	15.18	54.34	423.23	4.0	474
63-S	0.60	31.0	15.10	54.63	407.29	4.00	477	31.2	15.18	54.46	418.86	4.0	471
64-N	0.60	31.0	15.10	54.70	404.11	4.00	476	31.2	15.18	54.37	423.83	4.0	478
Average	-	-	-	54.67	406.03	4.00	475	-	-	54.41	421.20	4.0	473
74-N	0.60	31.0	15.10	45.49	223.40	3.50	380	31.2	15.18	45.33	230.04	3.0	391
75-S	0.60	31.0	15.10	45.41	223.97	3.50	382	31.2	15.18	45.28	236.69	3.0	394
76-N	0.60	31.0	15.10	45.49	219.08	3.50	380	31.2	15.18	45.38	228.78	3.0	387
Average	-	-	-	45.45	222.60	3.50	381	-	-	45.32	233.05	3.0	391
33-S	0.65	35.0	16.81	67.49	1115.22	8.50	838	35.0	16.81	67.17	1097.60	8.0	825
34-N	0.65	35.0	16.81	68.53	1132.87	8.50	837	35.0	16.81	67.79	1104.95	8.0	822
35-S	0.65	35.0	16.81	67.47	1111.32	8.50	840	35.0	16.81	67.15	1098.75	8.0	810
Average	-	-	-	68.00	1123.07	8.50	838	-	-	67.47	1101.56	8.0	820
53-S	0.65	35.0	16.81	63.41	868.09	7.00	715	35.0	16.81	62.91	879.81	7.1	719
54-N	0.65	35.0	16.81	63.38	879.31	7.00	727	35.0	16.81	62.78	894.42	7.0	725
55-S	0.65	35.0	16.81	63.30	878.11	7.00	720	35.0	16.81	62.86	885.27	6.9	719
Average	-	-	-	63.37	876.20	7.00	722	-	-	62.83	888.48	7.0	722
65-S	0.65	35.0	16.81	53.44	496.35	5.00	531	35.0	16.81	53.33	516.24	4.9	542
66-N	0.65	35.0	16.81	53.47	499.52	5.00	538	35.0	16.81	53.24	521.74	5.0	543
67-S	0.65	35.0	16.81	53.47	503.15	5.00	539	35.0	16.81	53.33	516.71	5.0	539
Average	-	-	-	53.46	499.63	5.00	536	-	-	53.28	519.11	5.0	542
68-N	0.65	35.0	16.81	46.00	301.80	4.00	445	35.0	16.81	45.24	302.51	3.5	435
69-S	0.65	35.0	16.81	46.05	303.96	4.00	440	35.0	16.81	45.31	298.00	3.5	435
70-N	0.65	35.0	16.81	46.03	303.55	4.00	440	35.0	16.81	46.14	321.20	4.0	440
Average	-	-	-	46.03	303.32	4.00	441	-	-	45.50	304.93	3.6	436
77-S	0.65	35.0	16.81	48.24	354.12	4.00	472	35.0	16.81	48.11	363.47	4.0	471
78-N	0.65	35.0	16.81	48.39	351.24	4.00	473	35.0	16.81	48.16	360.82	4.0	472
79-S	0.65	35.0	16.81	48.29	357.06	4.00	476	35.0	16.81	48.11	365.13	4.0	471
Average	-	-	-	48.33	353.41	4.00	473	-	-	48.13	362.56	4.0	471

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TABLE 38

STANDARDIZATION TRIALS: PROPELLERS FITTED WITH SINUSOIDAL LINKAGE UNDER LANDING CONDITION

ller			Port Propeller														
SHP	Eng Rack (mm.)	Exh. Temp. (°F)	Blade Angle (deg.)	Pitch (ft.)	RPM	SHP	Eng. Rack (mm.)	Exh. Temp. (°F)	RPM (avg.)	SHP (total)	Observed Speed (k.)	Wind Vel. (k.)	Wind Dir.	Pitch (avg. ft.)	Apparent Slip	EHP	EHP/SHP
495.54	4.00	495	16.5	8.325	78.71	469.85	3.8	519	78.87	965.39	6.69	23.4	330	8.374	-	-	-
488.48	4.00	493	16.5	8.325	78.25	443.89	3.5	509	78.65	932.37	7.60	16.0	115	8.374	-	-	-
485.53	4.00	499	16.5	8.325	78.45	441.90	3.9	51[illegible]	78.74	927.43	6.76	24.2	330	8.374	-	-	-
489.51	4.00	495	-	-	78.41	449.88	3.6	514	78.73	939.39	7.16	-	-	8.374	-0.100	195	0.2076
418.24	3.50	462	16.5	8.325	78.82	489.61	4.1	533	77.12	907.85	7.54	17.7	100	8.374	-	-	-
410.97	3.50	465	16.5	8.325	76.57	478.25	3.9	505	76.19	889.22	6.47	24.8	330	8.374	-	-	-
414.60	3.50	463	-	-	77.69	483.93	4.0	519	76.75	898.53	7.00	-	-	8.374	-0.104	180	0.2003
317.08	3.00	419	16.5	8.325	69.07	344.86	3.0	551	69.52	661.94	4.84	25.7	320	8.374	-	-	-
330.36	3.10	428	16.5	8.325	69.13	297.06	3.0	422	69.50	627.42	7.60	21.7	80	8.374	-	-	-
323.72	3.05	423	-	-	69.10	320.96	3.0	486	69.51	644.68	6.22	-	-	8.374	-0.083	120	0.1860
236.41	3.00	380	16.5	8.325	59.90	184.39	2.5	342	61.12	420.80	4.23	21.8	70	8.374	-	-	-
221.01	3.00	375	16.5	8.325	59.77	206.21	2.5	359	61.15	427.22	6.69	24.6	270	8.374	-	-	-
228.71	3.00	377	-	-	59.83	195.30	2.5	350	61.13	424.01	5.46	-	-	8.374	-0.081	-	-
266.16	3.00	404	16.5	8.325	63.70	232.49	2.5	377	63.54	498.65	4.76	33.3	75	8.374	-	-	-
235.30	3.00	379	16.5	8.325	63.45	259.56	2.9	385	63.54	494.86	6.26	23.4	325	8.374	-	-	-
261.13	3.00	385	16.5	8.325	63.73	227.33	2.5	366	63.52	488.46	4.61	29.8	70	8.374	-	-	-
249.47	3.00	387	-	-	63.58	244.73	2.7	378	63.53	494.21	5.47	-	-	8.374	-0.042	-	-
222.07	3.00	370	16.5	8.325	63.08	238.04	2.5	383	63.26	460.11	5.91	2.9	210	8.374	-	-	-
235.52	3.00	380	16.5	8.325	63.01	242.54	3.0	386	63.18	478.06	5.76	19.0	30	8.374	-	-	-
222.40	3.00	370	16.5	8.32[illegible]	61.62	231.26	2.5	382	62.51	453.66	6.17	12.1	240	8.374	-	-	-
228.88	3.00	375	-	-	62.68	238.59	2.7	384	63.03	467.47	5.90	-	-	8.374	-0.133	-	-
752.05	5.40	598	23.9	11.87	78.09	878.13	5.8	635	77.80	1630.18	8.74	14.9	115	11.87	-	-	-
741.66	5.00	590	23.9	11.87	79.16	914.12	6.0	692	78.48	1655.78	8.46	25.9	330	11.87	-	-	-
746.85	5.20	594	-	-	78.62	896.12	5.9	647	78.14	1642.98	8.60	-	-	11.87	0.060	335	0.2039
610.08	5.00	523	23.9	11.87	73.15	695.63	5.1	622	73.55	1305.71	7.42	27.8	325	11.87	-	-	-
625.15	5.00	555	23.9	11.87	73.36	666.87	4.9	610	73.60	1292.02	8.83	20.2	90	11.87	-	-	-
663.69	5.10	568	23.9	11.87	73.07	719.10	5.1	623	74.10	1382.79	7.18	28.5	330	11.87	-	-	-
631.02	5.00	550	-	-	73.23	687.12	5.0	616	73.71	1318.13	8.06	-	-	11.87	0.067	280	0.2124
551.38	4.50	510	23.9	11.87	69.74	607.98	4.4	570	69.93	1159.36	9.65	28.6	315	11.87	-	-	-
540.11	4.50	515	23.9	11.87	70.08	552.61	4.5	560	70.08	1092.72	6.63	22.4	100	11.87	-	-	-
545.74	4.50	512	-	-	69.91	580.29	4.5	565	70.00	1126.04	8.14	-	-	11.87	0.038	260	0.2309
386.32	3.50	445	23.9	11.87	63.71	443.15	4.0	493	63.63	829.47	6.08	23.2	315	11.87	-	-	-
397.26	3.50	446	23.9	11.87	64.90	421.00	3.5	481	64.66	818.26	8.50	-	105	11.87	-	-	-
385.88	3.50	445	23.9	11.87	63.74	444.67	4.0	499	63.65	830.55	6.14	21.3	330	11.87	-	-	-
391.68	3.50	445	-	-	64.31	432.45	3.7	488	64.15	824.13	7.30	-	-	11.87	0.028	200	0.2430
221.90	3.00	356	23.9	11.87	54.80	251.72	3.0	361	54.61	473.62	6.67	13.6	300	11.87	-	-	-
229.84	3.00	353	23.9	11.87	54.95	239.52	3.0	359	54.66	469.36	5.85	15.3	60	11.87	-	-	-
221.03	3.00	359	23.9	11.87	54.85	253.42	3.1	363	54.66	474.45	7.00	14.7	315	11.87	-	-	-
225.65	3.00	355	-	-	54.89	246.04	3.0	360	54.65	471.70	6.34	-	-	11.87	0.010	135	0.2860
1002.38	6.80	719	27.5	13.53	75.98	1012.94	6.7	750	76.21	2015.32	10.00	19.5	85	13.53	-	-	-
968.58	6.50	700	27.5	13.53	74.69	957.74	6.5	715	75.50	1926.23	8.12	27.1	325	13.53	-	-	-
994.51	6.50	713	27.5	13.53	74.69	963.91	6.4	711	75.44	1958.42	10.04	20.0	85	13.53	-	-	-
983.51	6.60	708	-	-	75.01	973.08	6.5	723	75.66	1956.55	9.07	-	-	13.53	0.102	400	0.2040
740.25	5.50	617	27.5	13.53	71.62	813.24	5.5	662	71.51	1553.49	9.49	14.8	250	13.53	-	-	-
810.23	6.00	654	27.5	13.53	71.51	821.45	5.5	665	71.73	1631.68	7.87	26.0	30	13.53	-	-	-
775.24	5.70	635	-	-	71.56	817.34	5.5	663	71.62	1592.58	8.68	-	-	13.53	0.092	345	0.2170
559.97	4.60	526	27.5	13.53	63.21	507.97	4.2	536	63.92	1067.94	8.99	15.2	90	13.53	-	-	-
488.57	4.50	510	27.5	13.53	61.48	523.25	4.5	550	62.27	1011.82	6.95	21.0	330	13.53	-	-	-
502.00	-	-	27.5	13.53	63.58	519.31	-	-	63.28	1021.31	8.71	14.0	70	13.53	-	-	-
509.78	4.50	518	-	-	62.44	518.44	4.3	543	62.93	1028.22	7.90	-	-	13.53	0.060	260	0.2530
294.25	3.50	406	27.5	13.53	54.25	310.10	3.0	401	54.00	604.35	6.33	11.4	60	13.53	-	-	-
288.36	3.50	406	27.5	13.53	54.17	323.40	3.2	414	53.99	611.76	7.84	15.3	300	13.53	-	-	-
300.29	3.50	414	27.5	13.53	54.27	311.30	3.0	409	53.99	611.59	6.19	16.3	50	13.53	-	-	-
292.81	3.50	408	-	-	54.21	317.05	3.1	409	53.99	609.86	7.05	-	-	13.53	0.022	190	0.3120
191.65	3.00	363	27.5	13.53	45.76	197.58	3.0	367	45.81	389.23	6.14	18.7	25	13.53	-	-	-
180.59	3.00	342	27.5	13.53	45.82	193.41	3.0	360	45.98	374.00	5.55	10.9	260	13.53	-	-	-
184.41	3.00	357	27.5	13.53	45.83	193.47	3.0	359	45.87	377.88	6.35	16.1	25	13.53	-	-	-
184.31	3.00	35[illegible]	-	-	45.81	194.47	3.0	361	45.91	378.78	5.90	-	-	13.53	0.037	110	0.2900
1019.25	7.10	758	31.2	15.18	70.13	987.10	7.0	768	70.68	2000.63	10.26	15.7	260	15.14	-	-	-
1014.11	7.20	748	31.2	15.18	69.75	983.26	7.0	763	69.98	1997.37	8.34	25.3	30	15.14	-	-	-
985.58	7.10	736	31.2	15.18	69.85	967.37	6.8	750	70.07	1952.08	10.34	12.8	255	15.14	-	-	-
1008.26	7.10	747	-	-	69.87	980.25	6.9	761	70.18	1986.86	9.32	-	-	15.14	0.111	430	0.2160
595.53	5.00	562	31.2	15.18	62.13	694.78	5.4	613	62.06	1290.31	7.69	18.4	325	15.14	-	-	-
5[illegible]1.05	5.00	560	31.2	15.18	62.24	681.50	5.5	604	62.10	1272.55	8.91	11.8	70	15.14	-	-	-
587.25	5.00	558	31.2	15.18	62.16	689.97	5.5	611	62.10	1277.22	8.04	18.0	330	15.14	-	-	-
591.22	5.00	560	-	-	62.19	686.94	5.5	608	62.09	1278.16	8.39	-	-	15.14	0.096	315	0.2460
405.44	4.00	469	31.2	15.18	54.34	423.23	4.0	474	54.53	828.67	8.43	17.2	300	15.14	-	-	-
407.29	4.00	477	31.2	15.18	54.46	418.88	4.0	471	54.54	826.17	6.78	16.4	65	15.14	-	-	-
404.11	4.00	476	31.2	15.18	54.37	423.83	4.0	478	54.53	827.94	8.34	15.5	315	15.14	-	-	-
406.03	4.00	475	-	-	54.41	421.20	4.0	473	54.53	827.24	7.58	-	-	15.14	0.070	230	0.2780
223.40	3.50	380	31.2	15.18	45.33	230.04	3.0	391	45.41	453.44	5.96	4.5	270	15.14	-	-	-
223.97	3.50	382	31.2	15.18	45.28	236.69	3.0	394	45.34	460.66	6.68	14.3	5	15.14	-	-	-
219.08	3.50	380	31.2	15.18	45.38	228.78	3.0	387	45.43	447.86	6.06	3.5	240-360	15.14	-	-	-
222.60	3.50	381	-	-	45.32	233.05	3.0	391	45.38	455.65	6.34	-	-	-	0.065	140	0.3070
1115.22	8.50	838	35.0	16.81	67.17	1097.60	8.0	825	67.33	2212.82	8.03	28.7	25	16.81	-	-	-
1132.87	8.50	837	35.0	16.81	67.79	1104.95	8.0	822	68.16	2237.82	10.95	14.2	255	16.81	-	-	-
1111.32	8.50	840	35.0	16.81	67.15	1098.75	8.0	810	67.31	2210.07	8.09	25.6	30	16.81	-	-	-
1123.07	8.50	838	-	-	67.47	1101.56	8.0	820	67.74	2224.63	9.50	-	-	-	0.155	460	0.2070
868.09	7.00	715	35.0	16.81	62.91	879.81	7.1	719	63.16	1747.90	9.32	10.2	70	16.81	-	-	-
879.31	7.00	727	35.0	16.81	62.78	894.42	7.0	725	63.08	1773.73	8.93	19.5	330	16.81	-	-	-
878.11	7.00	720	35.0	16.81	62.86	885.27	6.9	719	63.08	1763.38	9.14	12.8	60	16.81	-	-	-
876.20	7.00	722	-	-	62.83	888.48	7.0	722	63.10	1764.68	9.08	-	-	-	0.133	400	0.2270
496.35	5.00	531	35.0	16.81	53.33	516.24	4.9	542	53.38	1012.59	7.46	12.0	45	16.81	-	-	-
499.52	5.00	538	35.0	16.81	53.24	521.74	5.0	543	53.35	1021.26	8.47	15.9	315	16.81	-	-	-
503.15	5.00	539	35.0	16.81	53.33	516.71	5.0	539	53.40	1019.86	7.62	12.5	35	16.81	-	-	-
499.63	5.00	536	-	-	53.28	519.11	5.0	542	53.37	1018.74	8.00	-	-	-	0.096	270	0.2650
301.80	4.00	445	35.0	16.81	45.24	302.51	3.5	435	45.62	604.31	7.12	15.0	315	16.81	-	-	-
303.96	4.00	440	35.0	16.81	45.31	298.00	3.5	435	45.68	601.96	6.95	9.0	60	16.81	-	-	-
303.55	4.00	440	35.0	16.81	46.14	321.20	4.0	440	46.08	624.75	6.89	12.0	330	16.81	-	-	-
303.32	4.00	441	-	-	45.50	304.93	3.6	436	45.76	608.24	6.98	-	-	-	0.080	180	0.2960
354.12	4.00	472	35.0	16.81	48.11	363.47	4.0	471	48.17	717.59	7.63	11.7	15	16.81	-	-	-
351.24	4.00	473	35.0	16.81	48.16	360.82	4.0	472	48.27	712.06	6.98	9.4	290	16.81	-	-	-
357.06	4.00	476	35.0	16.81	48.11	365.13	4.0	471	48.20	722.19	7.39	15.8	15	16.81	-	-	-
353.41	4.00	473	-	-	48.13	362.56	4.0	471	48.23	715.97	7.24	-	-	-	0.095	200	0.2790

TABLE 39

STANDARDIZATION TRIALS: PROPELLERS FITTED WITH ROTOR "A" LINKAGE UNDER LAND

Run and Dir.	* Pitch Setting	Starboard Propeller Blade Angle (deg.)	Pitch (ft.)	RPM	SHP	Eng. Rack (mm.)	Exh. Temp. (° F)	Port Propeller Blade Angle (deg.)	Pitch (ft.)	RPM	SHP	Eng. Rack (mm.)	Exh. Temp. (° F)	RPM (avg.)
84-N	0.40	21.8	10.90	73.70	306	4.0	440	22.0	10.98	73.19	283	4.0	460	73.76
85-S	0.40	21.8	10.90	73.61	307	4.0	445	22.0	10.98	72.86	279	4.0	440	73.23
86-N	0.40	21.8	10.90	73.47	300	4.0	440	22.0	10.98	72.77	272	4.0	460	73.12
Average	-	-	-	73.60	305	4.0	442	-	-	72.92	278	4.0	450	73.33
96-N	0.40	21.8	10.90	70.80	253	4.0	410	22.0	10.98	71.11	243	4.0	440	70.95
97-S	0.40	21.8	10.90	70.63	265	4.0	425	22.0	10.98	70.97	253	4.0	430	70.80
98-N	0.40	21.8	10.90	70.79	247	4.0	420	22.0	10.98	71.07	239	4.0	440	70.93
Average	-	-	-	70.71	257	4.0	420	-	-	71.03	247	4.0	435	70.87
111-S	0.40	21.8	10.90	63.87	191	3.5	375	22.0	10.98	64.05	200	3.5	380	63.96
112-N	0.40	21.8	10.90	64.05	185	3.5	370	22.0	10.98	64.13	184	3.5	380	64.09
113-S	0.40	21.8	10.90	63.90	193	3.5	380	22.0	10.98	64.00	200	3.5	390	63.95
Average	-	-	-	63.97	188	3.5	374	-	-	64.08	192	3.5	382	64.02
87-S	0.50	28.9	14.26	74.61	468	5.0	510	29.3	14.29	74.79	432	5.0	520	74.70
88-N	0.50	28.9	14.26	74.62	462	5.0	510	29.3	14.29	74.90	427	5.0	520	74.76
89-S	0.50	28.9	14.26	74.53	464	5.0	515	29.3	14.29	74.81	429	5.0	520	74.67
Average	-	-	-	74.59	464	5.0	511	-	-	74.85	429	5.0	520	74.72
99-S	0.50	28.9	14.26	70.37	409	4.5	485	29.3	14.29	70.26	386	4.5	515	70.49
100-N	0.50	28.9	14.26	70.89	375	5.0	470	29.3	14.29	70.45	354	4.0	500	70.67
101-S	0.50	28.9	14.26	70.22	391	4.5	495	29.3	14.29	70.26	378	4.5	510	70.24
Average	-	-	-	70.59	387	4.7	480	-	-	70.35	368	4.2	506	70.52
114-N	0.50	28.9	14.26	64.70	280	4.0	425	29.3	14.29	64.47	274	4.0	430	64.58
115-S	0.50	28.9	14.26	64.78	288	4.0	425	29.3	14.29	64.26	292	4.0	430	64.52
116-N	0.50	28.9	14.26	64.68	280	4.0	410	29.3	14.29	64.44	273	4.0	420	64.56
Average	-	-	-	64.73	284	4.0	421	-	-	64.36	283	4.0	427	64.54
135-S	0.50	28.9	14.26	55.28	182	4.0	375	29.3	14.29	55.42	165	4.0	350	55.35
136-N	0.50	28.9	14.26	55.21	185	4.0	380	29.3	14.29	55.32	182	4.0	370	55.26
137-S	0.50	28.9	14.26	55.15	186	4.0	370	29.3	14.29	55.42	169	4.0	360	55.28
Average	-	-	-	55.21	184	4.0	376	-	-	55.37	174	4.0	362	55.29
90-N	0.55	32.2	15.62	73.81	582	5.5	545	33.2	16.05	74.22	502	5.5	580	74.01
91-S	0.55	32.2	15.62	74.12	526	5.5	525	33.2	16.05	74.10	509	5.5	590	74.11
92-N	0.55	32.2	15.62	73.32	593	5.5	560	33.2	16.05	74.25	488	5.0	580	73.78
Average	-	-	-	73.84	557	5.5	539	-	-	74.17	502	5.4	585	74.00
102-N	0.55	32.2	15.62	70.49	450	5.0	520	33.2	16.05	70.88	448	5.0	550	70.68
103-S	0.55	32.2	15.62	70.80	475	5.0	530	33.2	16.05	70.65	474	5.0	560	70.72
104-N	0.55	32.2	15.62	71.02	458	5.0	520	33.2	16.05	70.89	450	5.0	550	70.95
Average	-	-	-	70.78	464	5.0	525	-	-	70.77	461	5.0	555	70.77
117-S	0.55	32.2	15.62	64.34	363	5.0	470	33.2	16.05	64.48	360	4.5	480	64.41
118-N	0.55	32.2	15.62	64.47	353	4.5	450	33.2	16.05	64.61	346	4.5	500	64.54
119-S	0.55	32.2	15.62	65.35	394	4.0	470	33.2	16.05	64.34	362	4.0	480	64.84
Average	-	-	-	64.66	366	4.5	460	-	-	64.51	353	4.4	490	64.58
132-N	0.55	32.2	15.62	55.78	238	4.0	405	33.2	16.05	55.52	241	4.0	410	55.65
133-S	0.55	32.2	15.62	55.81	246	4.0	410	33.2	16.05	55.71	227	4.0	410	55.76
134-N	0.55	32.2	15.62	55.70	239	4.0	405	33.2	16.05	55.54	237	4.0	410	55.62
Average	-	-	-	55.77	242	4.0	407	-	-	55.62	233	4.0	410	55.70
138-N	0.55	32.2	15.62	45.80	129	4.0	320	33.2	16.05	45.85	129	4.0	335	45.82
139-S	0.55	32.2	15.62	46.25	129	4.0	350	33.2	16.05	46.02	120	4.0	320	46.13
140-N	0.55	32.2	15.62	46.27	129	4.0	350	33.2	16.05	45.88	132	4.0	360	46.07
Average	-	-	-	46.14	129	4.0	342	-	-	45.94	125	4.0	334	46.04
93-S	0.60	35.9	17.20	75.55	1063	8.0	780	37.5	17.80	74.68	799	7.0	735	75.11
94-N	0.60	35.9	17.20	75.37	989	8.0	770	37.5	17.80	74.68	775	7.5	720	75.02
95-S	0.60	35.9	17.20	74.66	1012	8.0	770	37.5	17.80	74.69	772	8.0	700	74.67
Average	-	-	-	75.24	1013	8.0	772	-	-	74.68	780	7.5	719	74.95
105-S	0.60	35.9	17.20	70.59	805	7.0	660	37.5	17.80	71.75	640	6.0	625	71.17
106-N	0.60	35.9	17.20	71.59	794	7.5	690	37.5	17.80	72.15	598	6.0	630	71.87
107-S	0.60	35.9	17.20	71.56	664	5.0	615	37.5	17.80	71.50	675	7.0	50	71.53
Average	-	-	-	71.33	764	6.7	664	-	-	71.89	628	6.2	634	71.61
120-N	0.60	35.9	17.20	63.90	423	5.0	500	37.5	17.80	64.13	450	5.0	530	64.01
121-S	0.60	35.9	17.20	64.39	447	5.0	480	37.5	17.80	64.26	423	5.0	520	64.32
122-N	0.60	35.9	17.20	63.84	420	5.0	490	37.5	17.80	64.08	440	5.0	520	63.96
Average	-	-	-	64.13	434	5.0	487	-	-	64.18	434	5.0	522	64.15
129-S	0.60	35.9	17.20	54.86	268	4.0	420	37.5	17.80	55.45	258	4.0	420	55.15
130-N	0.60	35.9	17.20	56.42	294	4.0	440	37.5	17.80	55.26	274	4.0	435	55.84
131-S	0.60	35.9	17.20	56.65	298	4.0	440	37.5	17.80	55.48	260	4.0	430	56.06
Average	-	-	-	56.09	288	4.0	435	-	-	55.36	266	4.0	430	55.72
141-S	0.60	35.9	17.20	45.75	149	4.0	350	37.5	17.80	45.43	149	4.0	360	45.59
142-N	0.60	35.9	17.20	45.92	150	4.0	360	37.5	17.80	45.62	146	4.0	395	45.77
Average	-	-	-	45.83	149	4.0	355	-	-	45.52	147	4.0	377	45.68
108-N	0.65	39.8	18.76	71.62	910	7.0	720	41.8	19.54	72.04	820	7.0	725	71.83
109-S	0.65	39.8	18.76	71.57	833	8.0	730	41.8	19.54	71.89	856	7.0	730	71.73
110-N	0.65	39.8	18.76	71.67	831	7.0	715	41.8	19.54	72.06	845	7.0	720	71.86
Average	-	-	-	71.61	852	7.5	724	-	-	71.97	844	7.0	726	71.79
123-S	0.65	39.8	18.76	63.54	488	6.0	515	41.8	19.54	64.19	568	6.0	610	63.86
124-N	0.65	39.8	18.76	63.16	457	5.5	520	41.8	19.54	63.82	611	6.0	630	63.49
125-S	0.65	39.8	18.76	63.60	494	6.0	550	41.8	19.54	63.89	602	6.0	620	63.74
Average	-	-	-	63.36	473	5.7	526	-	-	63.93	598	6.0	622	63.64
126-N	0.65	39.8	18.76	55.12	300	4.5	420	41.8	19.54	55.65	375	5.0	500	55.38
127-S	0.65	39.8	18.76	55.98	315	5.0	495	41.8	19.54	55.96	359	5.0	450	55.97
128-N	0.65	39.8	18.76	56.13	316	4.5	440	41.8	19.54	55.65	378	5.0	495	55.89
Average	-	-	-	55.80	311	4.7	462	-	-	55.80	368	5.0	474	55.80
143-S	0.65	39.8	18.76	45.23	165	-	-	41.8	19.54	44.95	182	-	-	45.09
144-N	0.65	39.8	18.76	45.44	175	-	-	41.8	19.54	44.92	179	-	-	45.18
Average	-	-	-	45.33	170	-	-	-	-	44.93	180	-	-	45.13

TABLE 39

STANDARDIZATION TRIALS: PROPELLERS FITTED WITH ROTOR "A" LINKAGE UNDER LANDING CONDITION

...peller SHP	Eng. Rack (mm.)	Exh. Temp. (° F)	Port Propeller Blade Angle (deg.)	Pitch (ft.)	RPM	SHP	Eng. Rack (mm.)	Exh. Temp. (° F)	RPM (avg.)	SHP (total)	Observed Speed (k.)	Wind Vel. (k.)	Wind Dir.	Pitch (avg. ft.)	Apparent Slip	EHP	EHP/SHP
306	4.0	440	22.0	10.98	73.19	283	4.0	460	73.76	589	7.04	-	305	-	-	-	-
307	4.0	445	22.0	10.98	72.86	279	4.0	440	73.23	586	5.76	-	015	-	-	-	-
300	4.0	440	22.0	10.98	72.77	272	4.0	460	73.12	572	7.28	-	037	-	-	-	-
305	4.0	442	-	-	72.92	278	4.0	450	73.33	583	6.46	-	-	10.940	19.11	140	0.24
253	4.0	410	22.0	10.98	71.11	243	4.0	440	70.95	496	5.67	-	175	-	-	-	-
265	4.0	425	22.0	10.98	70.97	253	4.0	430	70.80	518	6.37	-	007	-	-	-	-
247	4.0	420	22.0	10.98	71.07	239	4.0	440	70.93	486	5.73	-	175	-	-	-	-
257	4.0	420	-	-	71.03	247	4.0	435	70.87	504	6.04	-	-	10.940	21.13	115	0.23
191	3.5	375	22.0	10.98	64.05	200	3.5	380	63.96	391	4.26	-	345	-	-	-	-
185	3.5	370	22.0	10.98	64.13	184	3.5	380	64.09	369	6.62	-	140	-	-	-	-
193	3.5	380	22.0	10.98	64.00	200	3.5	390	63.95	393	4.36	-	345	-	-	-	-
188	3.5	374	-	-	64.08	192	3.5	382	64.02	380	5.46	-	-	10.940	24.29	-	-
468	5.0	510	29.3	14.29	74.79	432	5.0	520	74.70	900	7.25	-	350	-	-	-	-
462	5.0	510	29.3	14.29	74.90	427	5.0	520	74.76	889	9.00	-	030	-	-	-	-
464	5.0	515	29.3	14.29	74.81	429	5.0	520	74.67	891	7.32	-	345	-	-	-	-
464	5.0	511	-	-	74.85	429	5.0	520	74.72	892	8.14	-	-	14.270	25.06	280	0.31
409	4.5	485	29.3	14.29	70.26	386	4.5	515	70.49	795	7.63	-	000	-	-	-	-
375	5.0	470	29.3	14.29	70.45	354	4.0	500	70.67	729	7.58	-	170	-	-	-	-
391	4.5	495	29.3	14.29	70.26	378	4.5	510	70.24	769	7.54	-	000	-	-	-	-
387	4.7	480	-	-	70.35	368	4.2	506	70.52	756	7.58	-	-	14.270	23.66	235	0.31
280	4.0	425	29.3	14.29	64.47	274	4.0	430	64.58	554	7.86	-	135	-	-	-	-
288	4.0	425	29.3	14.29	64.26	292	4.0	430	64.52	580	6.09	-	342	-	-	-	-
280	4.0	410	29.3	14.29	64.44	273	4.0	420	64.56	553	7.61	-	132	-	-	-	-
284	4.0	421	-	-	64.36	283	4.0	427	64.54	567	6.91	-	-	14.270	25.06	178	0.31
182	4.0	375	29.3	14.29	55.42	165	4.0	350	55.35	347	5.57	11.2	105	-	-	-	-
185	4.0	380	29.3	14.29	55.32	182	4.0	370	55.26	367	6.49	16.3	310	-	-	-	-
186	4.0	370	29.3	14.29	55.42	169	4.0	360	55.28	355	5.31	12.2	080	-	-	-	-
184	4.0	376	-	-	55.37	174	4.0	362	55.29	359	5.96	-	-	14.270	24.07	110	0.31
582	5.5	545	33.2	16.05	74.22	502	5.5	580	74.01	1084	9.38	-	075	-	-	-	-
526	5.5	525	33.2	16.05	74.10	509	5.5	590	74.11	1035	8.01	-	355	-	-	-	-
593	5.5	560	33.2	16.05	74.25	488	5.0	580	73.78	1081	9.42	-	035	-	-	-	-
557	5.5	539	-	-	74.17	502	5.4	585	74.00	1059	8.70	-	-	15.820	25.19	350	0.33
450	5.0	520	33.2	16.05	70.88	448	5.0	550	70.68	898	8.56	-	150	-	-	-	-
475	5.0	530	33.2	16.05	70.65	474	5.0	560	70.72	949	8.01	-	350	-	-	-	-
458	5.0	520	33.2	16.05	70.89	450	5.0	550	70.95	908	8.82	-	140	-	-	-	-
464	5.0	525	-	-	70.77	461	5.0	555	70.77	926	8.35	-	-	15.820	24.85	305	0.33
363	5.0	470	33.2	16.05	64.48	360	4.5	480	64.41	723	7.07	-	347	-	-	-	-
353	4.5	450	33.2	16.05	64.61	346	4.5	500	64.54	699	8.18	-	125	-	-	-	-
394	4.0	470	33.2	16.05	64.34	362	4.0	480	64.84	756	7.23	-	342	-	-	-	-
366	4.5	460	-	-	64.51	353	4.4	490	64.58	719	7.66	-	-	15.820	24.41	235	0.33
238	4.0	405	33.2	16.05	55.52	241	4.0	410	55.65	479	6.24	21.7	305	-	-	-	-
246	4.0	410	33.2	16.05	55.71	227	4.0	410	55.76	473	6.81	15.2	085	-	-	-	-
239	4.0	405	33.2	16.05	55.54	237	4.0	410	55.62	476	6.86	18.7	310	-	-	-	-
242	4.0	407	-	-	55.62	233	4.0	410	55.70	475	6.68	-	-	15.820	23.34	150	0.32
129	4.0	320	33.2	16.05	45.85	129	4.0	335	45.82	258	6.04	16.1	315	-	-	-	-
129	4.0	350	33.2	16.05	46.02	120	4.0	320	46.13	249	4.76	10.4	070	-	-	-	-
129	4.0	350	33.2	16.05	45.88	132	4.0	360	46.07	261	6.15	16.1	315	-	-	-	-
129	4.0	342	-	-	45.94	125	4.0	334	46.04	254	5.43	-	-	15.820	25.66	-	-
1063	8.0	780	37.5	17.80	74.68	799	7.0	735	75.11	1862	9.57	-	355	-	-	-	-
989	8.0	770	37.5	17.80	74.68	775	7.5	720	75.02	1764	10.48	-	045	-	-	-	-
1012	8.0	770	37.5	17.80	74.69	772	8.0	700	74.67	1784	9.80	-	357	-	-	-	-
1013	8.0	772	-	-	74.68	780	7.5	719	74.95	1794	10.08	-	-	17.500	22.27	560	0.31
805	7.0	660	37.5	17.80	71.75	640	6.0	625	71.17	1445	8.52	-	345	-	-	-	-
794	7.5	690	37.5	17.80	72.15	598	6.0	630	71.87	1392	10.45	-	105	-	-	-	-
664	5.0	615	37.5	17.80	71.50	675	7.0	50	71.53	1339	8.27	-	347	-	-	-	-
764	6.7	664	-	-	71.89	628	6.2	634	71.61	1392	9.42	-	-	17.500	24.75	445	0.32
423	5.0	500	37.5	17.80	64.13	450	5.0	530	64.01	873	6.91	22.3	315	-	-	-	-
447	5.0	480	37.5	17.80	64.26	423	5.0	520	64.32	870	9.60	18.2	090	-	-	-	-
420	5.0	490	37.5	17.80	64.08	440	5.0	520	63.96	860	6.87	23.0	290	-	-	-	-
434	5.0	487	-	-	64.18	434	5.0	522	64.15	868	8.24	-	-	17.500	27.67	295	0.34
268	4.0	420	37.5	17.80	55.45	258	4.0	420	55.15	526	7.89	16.7	090	-	-	-	-
294	4.0	440	37.5	17.80	55.26	274	4.0	435	55.84	568	6.38	19.6	325	-	-	-	-
298	4.0	440	37.5	17.80	55.48	260	4.0	430	56.06	558	8.02	12.1	070	-	-	-	-
288	4.0	435	-	-	55.36	266	4.0	430	55.72	555	7.17	-	-	17.500	27.78	200	0.36
149	4.0	350	37.5	17.80	45.43	149	4.0	360	45.59	298	6.70	11.9	335	-	-	-	-
150	4.0	360	37.5	17.80	45.62	146	4.0	395	45.77	296	5.33	5.4	065	-	-	-	-
149	4.0	355	-	-	45.52	147	4.0	377	45.68	297	6.02	-	-	17.500	24.77	115	0.39
910	7.0	720	41.8	19.54	72.04	820	7.0	725	71.83	1730	11.24	-	145	-	-	-	-
833	8.0	730	41.8	19.54	71.89	856	7.0	730	71.73	1689	8.82	-	352	-	-	-	-
831	7.0	715	41.8	19.54	72.06	845	7.0	720	71.86	1676	11.24	-	130	-	-	-	-
852	7.5	724	-	-	71.97	844	7.0	726	71.79	1696	10.03	-	-	19.165	27.22	550	0.33
488	6.0	515	41.8	19.54	64.19	568	6.0	610	63.86	1056	10.30	20.7	065	-	-	-	-
457	5.5	520	41.8	19.54	63.82	611	6.0	630	63.49	1068	7.34	21.7	300	-	-	-	-
492	6.0	550	41.8	19.54	63.89	602	6.0	620	63.74	1094	10.55	18.8	075	-	-	-	-
473	5.7	526	-	-	63.93	598	6.0	622	63.64	1072	8.88	-	-	19.165	28.44	370	0.35
300	4.5	420	41.8	19.54	55.65	375	5.0	500	55.38	675	6.26	22.0	315	-	-	-	-
315	5.0	495	41.8	19.54	55.96	359	5.0	450	55.97	674	9.38	16.7	090	-	-	-	-
316	4.5	440	41.8	19.54	55.65	378	5.0	495	55.89	694	6.30	22.4	315	-	-	-	-
311	4.7	462	-	-	55.80	368	5.0	474	55.80	679	7.83	-	-	19.165	28.71	250	0.37
165	-	-	41.8	19.54	44.95	182	-	-	45.09	347	7.17	11.6	345	-	-	-	-
175	-	-	41.8	19.54	44.92	179	-	-	45.18	354	5.41	5.4	040	-	-	-	-
170	-	-	-	-	44.93	180	-	-	45.13	350	6.29	-	-	19.165	27.74	135	0.39

Upon completion of the trials, shaft horsepower and rpm were plotted for 0.4π , 0.5π , 0.55π , 0.6π , and 0.65π pitches. Effective horsepower for the normal landing condition was taken from the David Taylor Model Basin self-propelled test (Determination One). Using these values for ehp, the propulsive coefficient $\frac{ehp}{shp}$ was calculated and plotted (Figures 29 through 33).

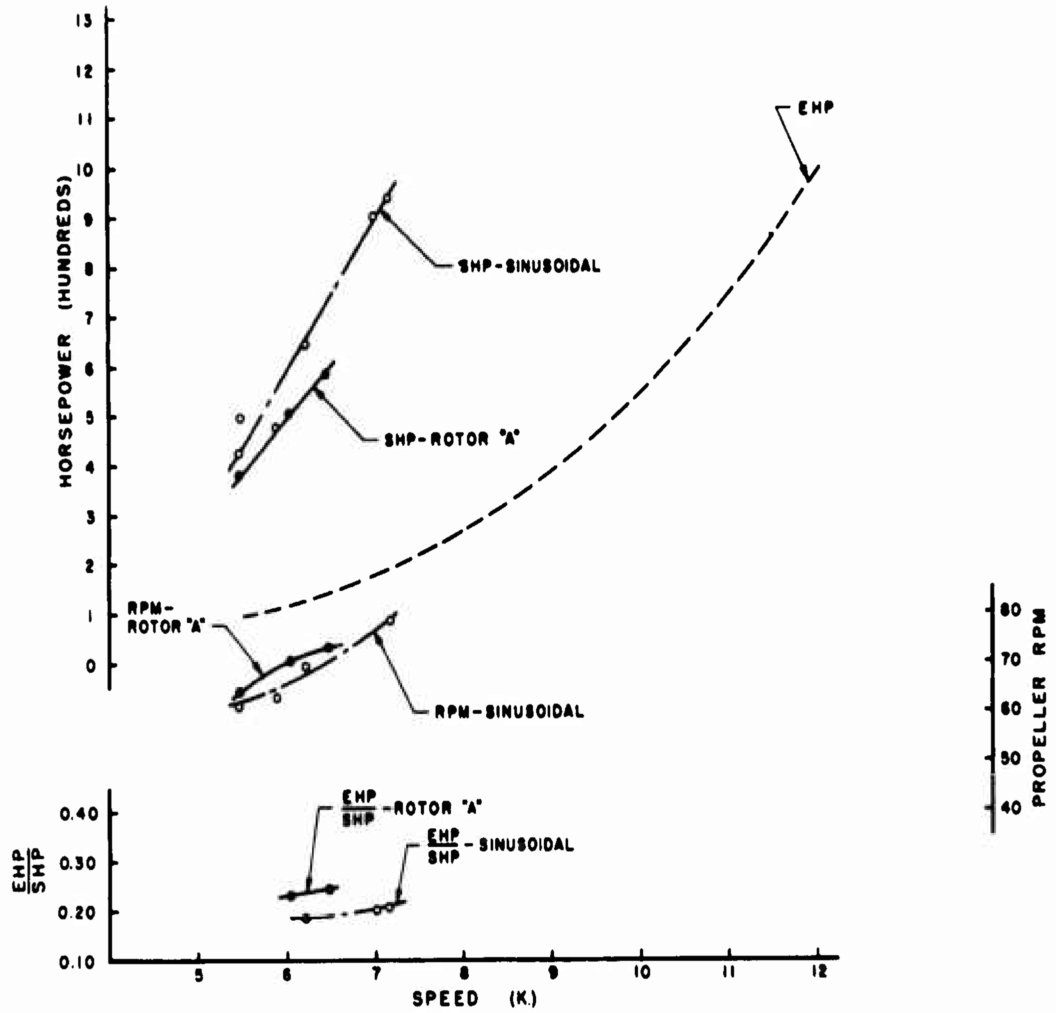

Figure 29. SHP, RPM, EHP, and Propulsive Coefficient (EHP/SHP) With Propellers at 0.4π Pitch (Rotor "A" and Sinusoidal Linkage).

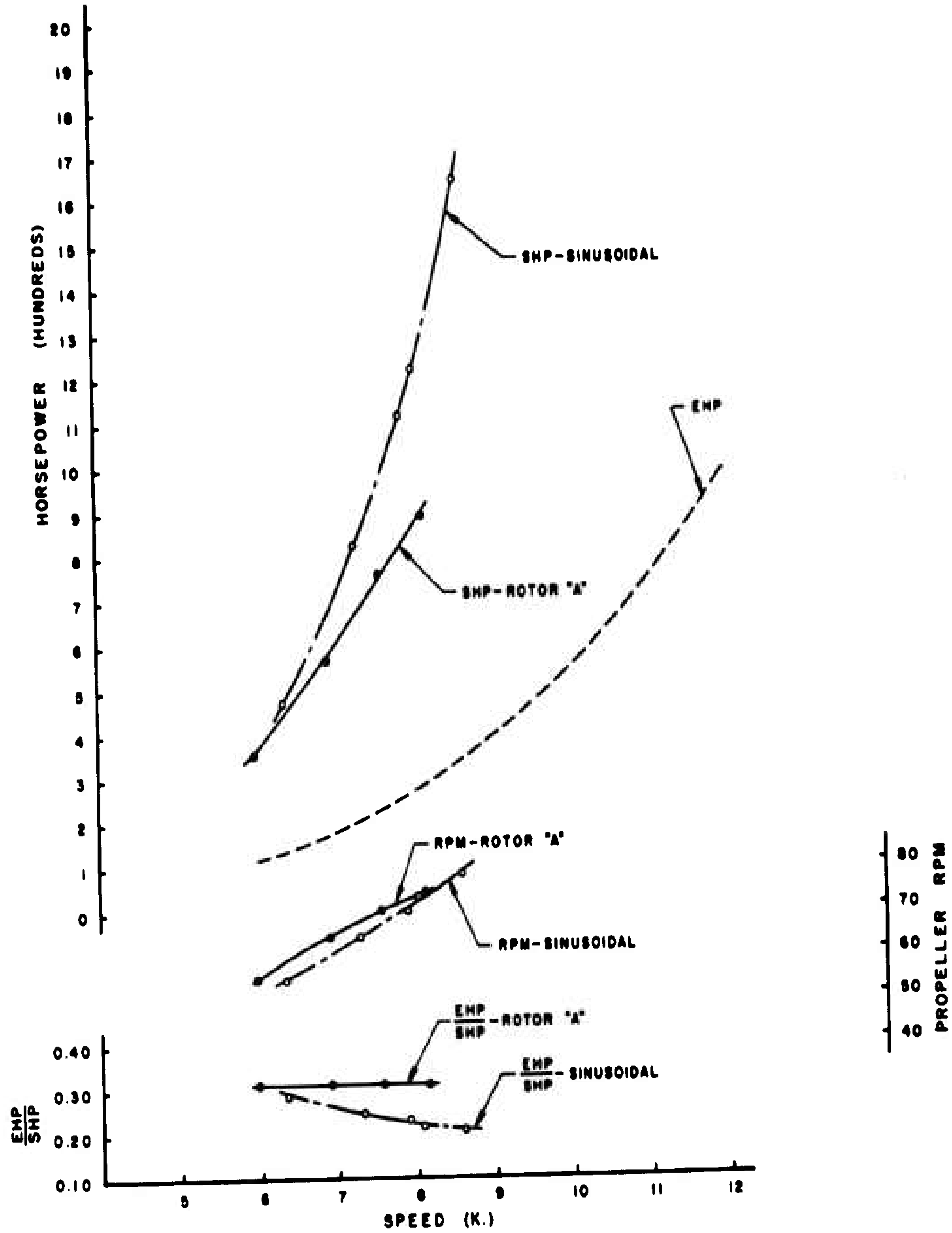

Figure 30. SHP, RPM, EHP, and Propulsive Coefficient (EHP/ SHP) With Propellers at 0.5π Pitch (Rotor "A" and Sinusoidal Linkage).

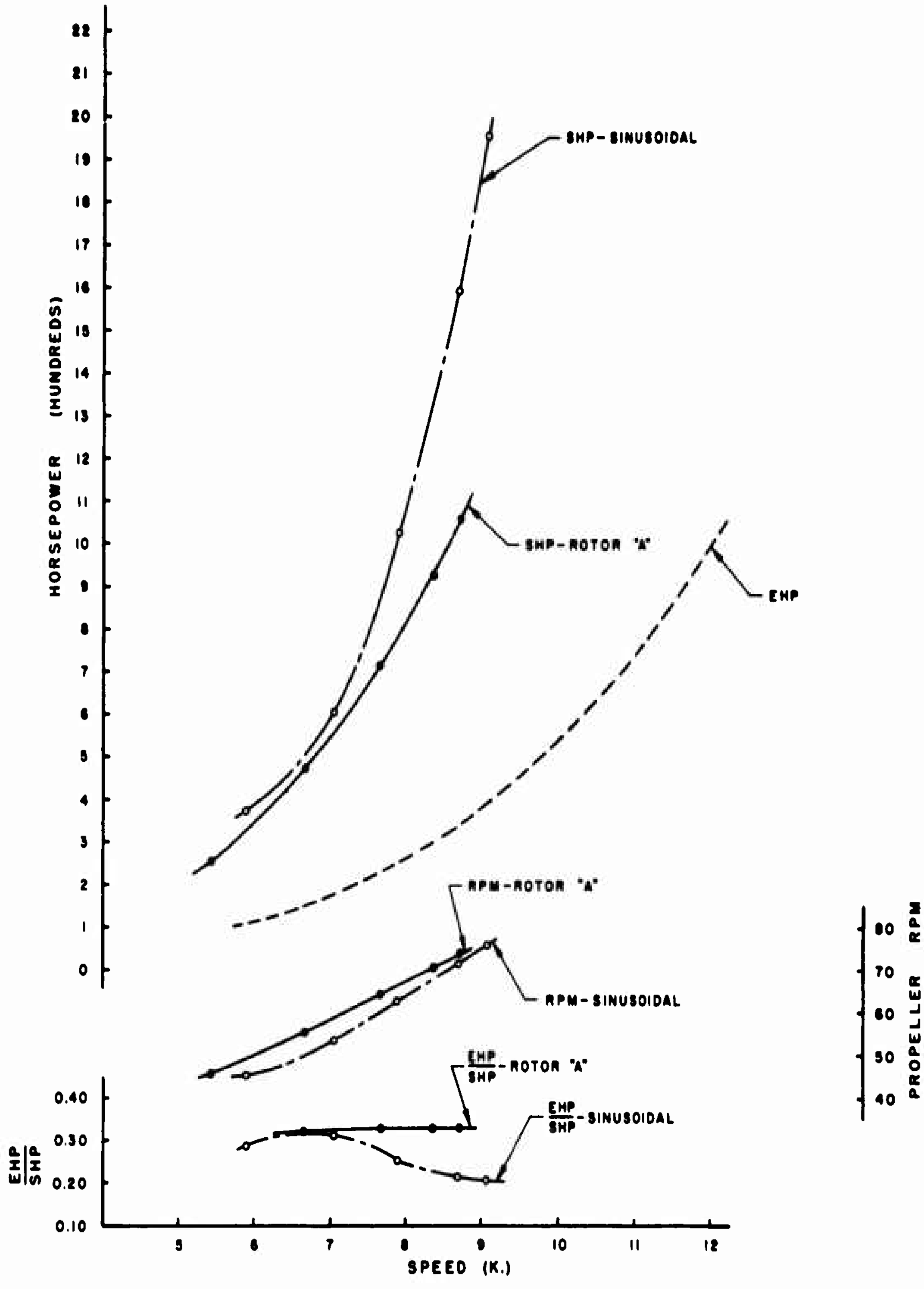

Figure 31. SHP, RPM, EHP, and Propulsive Coefficient (EHP/SHP) With Propellers at 0.55π Pitch (Rotor "A" and Sinusoidal Linkage).

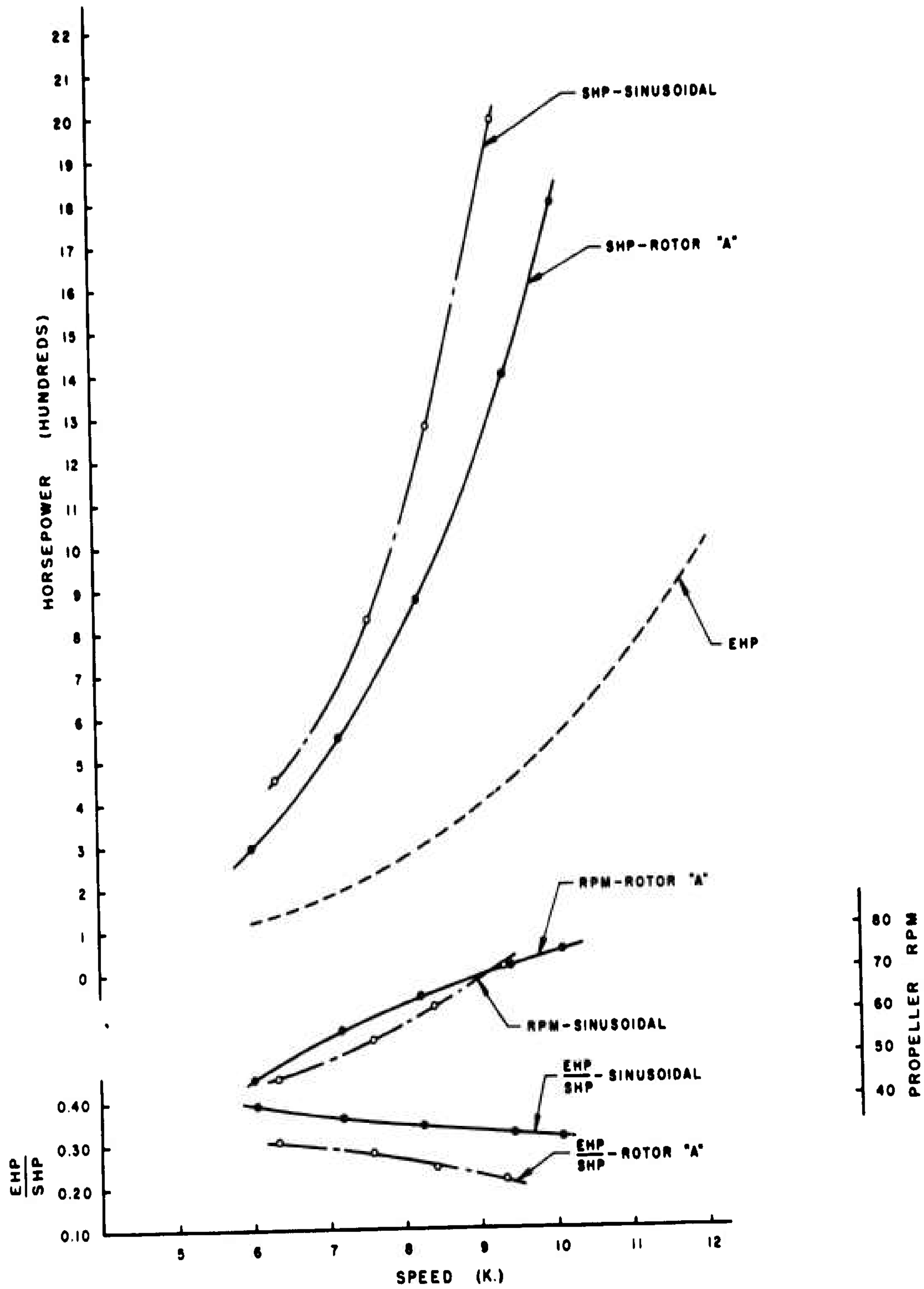

Figure 32. SHP, RPM, EHP, and Propulsive Coefficient (EHP/SHP) With Propellers at 0.6π Pitch (Rotor "A" and Sinusoidal Linkage).

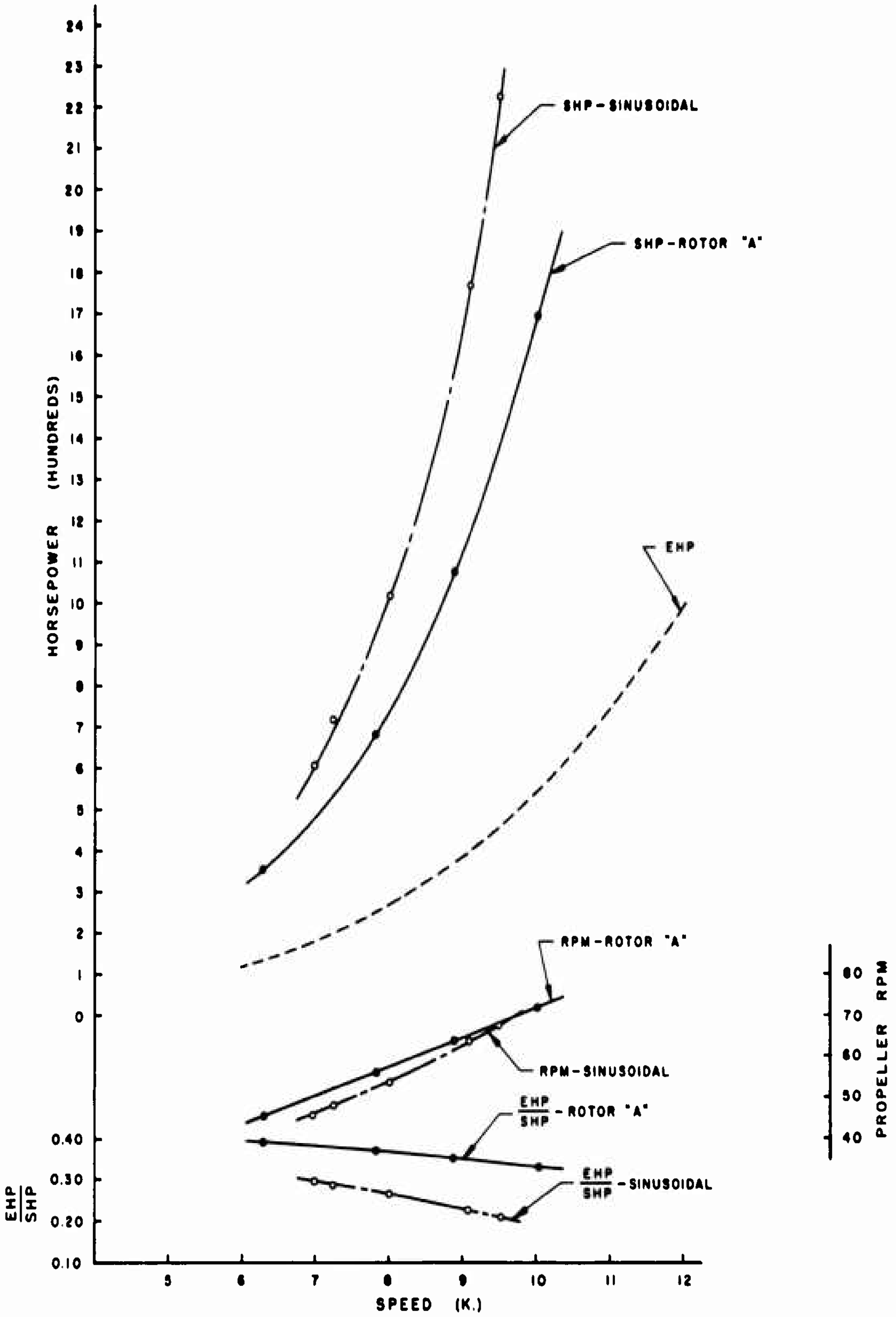

Figure 33. SHP, RPM, EHP, and Propulsive Coefficient (EHP/SHP) With Propellers at 0.65π Pitch (Rotor "A" and Sinusoidal Linkage).

The results of the no-load and the spin tests conducted by the manufacturer are given in Table 40 and Figure 34.

TABLE 40
NO-LOAD TEST: PROPELLERS FITTED WITH ROTOR "A" AND SINUSOIDAL LINKAGE (ZERO PITCH)

Type of Linkage	Run	Shaft RPM Stbd.	Shaft RPM Port	Prop. RPM Stbd.	Prop. RPM Port	Horsepower Stbd.	Horsepower Port
Rotor "A"	145	269.0	272.0	38.85	39.29	28.00	23.00
"	146	336.7	340.0	48.63	49.11	47.00	46.00
"	147	392.7	399.7	56.72	57.73	73.00	69.00
"	148	472.3	467.7	68.22	67.56	118.00	102.00
"	149	534.3	535.7	77.18	77.38	142.00	147.00
Sinusoidal	150	243.7	250.9	35.20	36.24	17.91	19.22
"	151	309.1	299.8	44.65	43.30	34.83	31.31
"	152	366.9	385.8	53.00	55.73	57.52	60.25
"	153	441.5	417.9	63.77	60.36	92.15	75.24
"	154	562.3	577.2	81.22	83.37	161.44	146.98

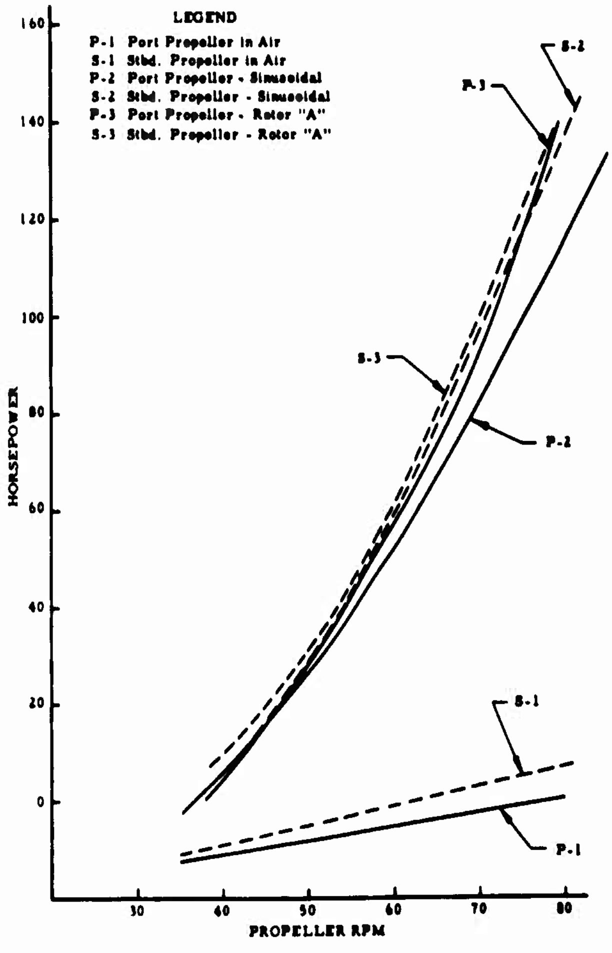

Figure 34. No-Load Tests With Propellers at Zero Pitch (Rotor "A" and Sinusoidal Linkage).

EVALUATION

Throughout the tests, the vertical-axis propellers demonstrated a capability of vessel control and maneuverability beyond that obtainable with other methods of propulsion. On numerous occasions, the vessel was operated in restricted areas and under conditions that would have been difficult or impossible with conventional propulsion. Beaching and retraction are accomplished without the use of a stern anchor. By being able to direct the desired thrust in any direction, the vessel is easily controlled in surf and can be held on beaches under any condition encountered. The ability to apply full thrust astern from 90 degrees port to 90 degrees starboard permits the vessel to be worked off a beach without the assistance of a stern anchor.

During operation it was discovered that difficulty was encountered in maintaining course. This was especially noticeable in the open sea and in heavy weather. At times, the change in the direction of thrust to maintain course was sufficient to adversely affect the vessel's headway. There have been instances of changes of as much as 40 degrees being required. From information available, this appears to be an inherent characteristic of the vertical-axis propellers. In some cases, this has been overcome; in twin installations, it has been accomplished by setting one propeller and steering with the other. However, this still results in some loss of ahead power due to the large changes in thrust on the propeller being used for steering. In view of this, it is believed that the use of a steadying skeg, or skegs, aft of the propellers should be investigated.

Considering the mechanical complexity of the vertical-axis propellers, the maintenance, so far, has not been excessive. The parts requiring replacement have been blade bearings, seals, and seal wear rings.

There were two types of main rotor bearings used: an "X" type and a tapered roller type. The "X" type failed and it was replaced with the tapered roller type. Since there have been no further failures to date, it is believed that the failure was due to the type of bearing. Also, wear was encountered on the main rotor seal wear ring. The major item encountered in maintenance was the labor involved in disassembly and assembly of the propellers. The parts, although commercial components, are not normally available from stock and must be manufactured to order.

The hull form has proven to be satisfactory for a vessel of this type. The spoon bow has neither produced excessive pounding in heavy weather nor created any problems in beaching or retraction. If anything, it is an asset in retraction. A problem given serious consideration during the preliminary design was the flooding of the ramp tunnel from boarding seas. This did not prove to be a problem during testing. In heavy weather, very little solid water was taken aboard. Water that did come aboard ran off the deck readily. As is characteristic of shallow-draft vessels, the bow of the vessel falls off in a beam wind or in a wind off the bow. This is further aggravated by the large sail area presented by the forecastle and island.

Early in the test, cracks appeared in the longitudinal shaft alley bulkheads in the area from frames 39 to 41. Later, similar cracks were discovered in transverse bulkhead 41. The vibration test indicated a propeller-excited vibration as the probable cause.

The addition of stiffeners to reduce the panel size and to change the natural frequency of the bulkheads did not prevent additional fractures. These bulkheads were then reinforced by the addition of larger stiffeners. Since reinforcement of the bulkheads, additional fractures have been found. It is not known whether these are new failures or old ones that were not previously discovered. The hull depth is less than that normally found in vessels of this size. Also, there is an abrupt change in the girder continuity in the area of bulkhead 41. Furthermore, the vessel is fitted with exceptionally high bulwarks, having a bulwark gate located just forward of frame 39. Although there has been no evidence of structural weakness in the hull, consideration should be given to the deletion of the bulwarks and to the increase of the hull depth in a future design.

Testing of off-loading alongside was limited to an operation with a single ship (Hickory Knoll). This was sufficient to establish that the vessel can be used for off-loading alongside for both general cargo and heavy lifts.

Model tests indicated that marriage with the Comet would be governed by the relative vertical motion between the two ships. A study of the model test results, mooring arrangements, and drafts of the two vessels during operating conditions established that the distance between the deck of the Page and the underside of the Comet's ramp would be the limiting factor. From this, it was determined that a safe working condition would exist with a relative vertical motion of up to 3 feet. Any sea condition that produced a relative vertical motion in excess of this would endanger both vessels.

The model tests further indicated that if the vessels were separated and maintained at a given distance apart, the safe relative vertical motion could be increased. The equipment for connecting the vessels and maintaining a specific horizontal distance between them would be complicated, heavy, and very difficult, if not impossible, to handle when the motion of the vessels exceeded that which can be tolerated with the vessels in contact. Also, it would complicate the operation under any condition. It was obvious that if the operation was to be a success, the mooring arrangement had to be the simplest possible, and that line handling and the equipment involved must be reduced to a minimum. This proved to be true in tests when additional lines were added.

During the test, the limiting factor was definitely the relative vertical motion. It occurred during the approach of the vessels rather than after the vessels were in contact and the mooring pendants were secured. Once the vessels are in contact and the mooring pendants secured, the vessels tend to pivot on the rubber fenders rather than to slide. However, during the approach, the vertical motion and the forces created therefrom must be absorbed by the warping lines. As the distance between the vessels decreases, these forces increase and part the warping lines.

The present arrangement will permit marriage of the vessels when the relative vertical motion is about 2 feet. This motion can be increased by securing the warping lines farther forward on the beach discharge lighter. Experience during the test indicated that this will not permit a marriage when the relative vertical motion exceeds 4 feet. This is not as serious a limitation as it appears. It should be noted that in the NODEX operation, when weather conditions did not permit accomplishment of the marriage, the vessels moved to another location and the mission was completed.

Another limiting factor that must be considered is the loading of the Comet. The Comet must be loaded such that it will arrive at destination with an after draft not in excess of 22 feet, or be capable of being ballasted to attain this draft. Also, vehicles on the second deck in way of the ramp tunnel must be loaded so they can be driven or towed directly from the vessel.

During the test, the Mark XXII gyrocompass was replaced with a Mark XIV, crew accommodations were increased, the sea chest was modified, additional ramp cleats were installed, main-deck manhole bolt protection rings were provided, a potable-water tank was installed, the echo sounding transducer was relocated, and the bow ramp sheaves were modified.

The Mark XXII gyrocompass was originally powered by a static power pack. The power pack proved to be unsatisfactory and was replaced with an inverter. This provided neither a suitable nor a dependable source of power. Operational experience demonstrated that the Mark XXII compass was not adequate for unrestricted operation of a vessel of this size. A Mark XIV gyrocompass system was installed and proved to be satisfactory.

The vessel was originally provided with crew accommodations for 6 officers and 24 enlisted men. The crew authorized was 7 officers and 24 enlisted men. In addition, a test engineer was assigned to the vessel. After the vessel had been delivered to the Army, it was decided to increase the crew by 10 enlisted men for the duration of the test. Accommodations for 4 officers and 10 enlisted men were installed in the truck drivers' compartment. Based upon experience during the test, it was determined that a crew of 8 officers and 32 enlisted men is required for unrestricted operation. It will be noted that the increase in crew accommodations was accomplished by reducing the space available for truck drivers. This did not affect the operation of the vessel, as more than ample space is available for truck drivers. In addition to crew requirements, at least one spare room should be provided for pilots and/or shore-based personnel required for the supervision and coordination of operations. In the future, a TOE should be established prior to the preparation of the contract plans and specifications.

Three sea chests were initially installed. One was located on the centerline and one outboard on each side. All sea chests were interconnected such that any one, all three, or any combination of two could be used. The sea chests were of the conventional submerged type, vented to above the main deck. Considerable difficulty was encountered with air in the salt-water systems, which caused the pumps to become airbound and the vents to foam. The outboard sea chests were changed to the free surface vented type. This stopped the foaming at the vents and the airbinding of pumps except in rough weather. The centerline sea chest was then changed to the same type. This eliminated the foaming at all vents and the airbinding of pumps except when running at light drafts in rough weather. When the sea chests were modified, the space available did not permit the increasing of the free area through the strainers, and therefore the velocity through the strainers remained unchanged. The outboard sea chests are too near the surface of the water and are of little value when running light or at any time in rough weather. Hence, the outboard sea chest should be deleted and a single large centerline sea chest of the free surface vented type should be provided. The free area through the strainer should be such that the water velocity does not exceed 4 feet per second.

Additional ramp cleats were added to reduce the spacing from 18 inches to 9 inches. Cleats spaced at 18 inches did not provide sufficient traction for the vehicles.

The design of the main-deck manholes and covers exposed both the studs and the nuts to tracked vehicles. A protection ring was installed on the covers of those in areas traversed by tracked vehicles. This was a temporary measure to protect the studs and nuts and not a correction for a design deficiency. Main-deck manholes should be of the flush type, similar to those developed by the U. S. Navy for decks subject to use by tracked vehicles.

Potable-water tanks were located between frames 26 and 27. These were shell tanks completely surrounded by ballast tanks without cofferdams. In a beaching type of vessel, it is considered that this arrangement is too vulnerable, and that there is too much of a risk of contaminating the vessel's potable-water supply from the possibility of damage sustained during beaching. A nonstructural potable-water tank was installed in the number 6 centerline ballast tank. On future vessels of this type, potable-water tanks should be of the nonstructural type and installed in such a manner as to be subjected to the least possible damage from beaching.

The echo sounding transducer was located aft of frame 23 to port of the centerline. In this location, the echo sounder would not give satisfactory soundings with the vessel underway. This was attributed to air under the forward part of the vessel. The transducer was relocated to a position in the skeg forward of frame 36. At this location, dependable soundings were obtained up to a speed of about 6 knots. Above this speed, soundings were erratic. No attempt was made to move the transducer farther aft because of the possibility of propeller interference. In future installations, further consideration should be given to transducer location and an attempt should be made to obtain a location where aeration is at a minimum.

In the original installation, circular sheaves were provided for the bow ramp chains. The diameter of these sheaves was limited by the space available to the extent that links in the chains were bent as the chains passed over the sheaves. This damage caused the failure of one of the chains. Both sheaves were replaced with a wildcat, or socket type, sheave.

The vessel was found to comply with, or to exceed, the requirements of the military characteristics, with the exception of speed. As previously noted, it is believed that the speed requirement should be reviewed and consideration given to operational requirements. The power required to obtain speeds in excess of that of other landing craft is greater than that which can be effectively used in a shallow-draft vessel of this type.

At 2,200 horsepower, the David Taylor Model Basin self-propelled test predicted a speed of 10.45 knots with the sinusoidal blade linkage, and 11.35 knots with the Rotor "A" type. During standardization trials, at a pitch setting of 0.65π, a maximum speed of 9.5 knots was attained with the sinusoidal linkage at 2,210 horsepower, and 10.03 knots with the Rotor "A" linkage at 1,696 horsepower. When the Rotor "A" linkage was operated at 0.65π pitch and full power, the oscillation of the control stick made operation so unsteady that reliable data could not be obtained. However, by extending the curve obtained at 0.65π pitch with the Rotor "A" linkage, it appears that the speed of 10.75 knots could be obtained with 2,200 horsepower.

The self-propelled tests at the David Taylor Model Basin indicated that with the Rotor "A" linkage, a speed of 12 knots could be obtained at landing displacement with 2,550 horsepower. Extrapolation of the standardization curve shows that approximately 3,200 horsepower would be required for 12 knots under the above conditions. This appears to be about the maximum size propeller that could be effectively installed in the hull envelope. In the primary mission, a requirement for speed in excess of 12 knots is doubtful. To obtain such speeds in this vessel, as well as in other types of logistical support craft, requires an expenditure of power that is not in consonance with the advantages to be gained.

BIBLIOGRAPHY

1. Buchman, Erich, and Birmingham, John T., Vibration Survey on U. S. Army Ship Lt. Col. John U. D. Page (BDL-1X), Report 1343, David Taylor Model Basin, Washington, D. C., June 1959.

2. Ficken, N. L., and Gawlik, S. G., Model Flow Studies to Investigate Propeller-Excited Vibrations on U. S. Army Ship Lt. Col. John U. D. Page (BDL-1X) Equipped Wtih Vertical-Axis Propellers, Report 1412, David Taylor Model Basin, Washington, D. C., March 1960.

3. Hundley, Emmett G., Correlation of Forces in Propeller Hydraulic Cylinders of U. S. Army Vessel Lt. Col. John U. D. Page, TCREC Technical Report 62-55, U. S. Army Transportation Research Command, Fort Eustis, Virginia, June 1962.

4. Johnson, William T., and Robinson, Walter C., Jr., Marriage Test of Beach Discharge Lighter (USAV Lt. Col. John U. D. Page) and USNS Comet, U. S. Army Transportation Research Command, Fort Eustis, Virginia, November 1959.

5. Lewis, Edward V., Model Test in Waves, Beach Lighter Moored to MSTS Cargo Ship, ETT Project FR 1722, Stevens Institute of Technology Experimental Towing Tank Letter Report No. 586, Hoboken, New Jersey, 31 October 1955.

6. Preliminary Report on Motions and Forces Between Beach Lighter and MSTS Cargo Ship Predicted From Model Test in Waves, Stevens Institute of Technology Experimental Towing Tank Letter Report No. 611, Hoboken, New Jersey, 17 May 1956.

7. Stora, Frank X., Towboat, River, Steel, Diesel, 120-Foot, U. S. Army Transportation Research Command, Fort Eustis, Virginia, November 1957.

APPENDIX I

Proposed Physical Characteristics

Length, overall	300 ft. 0 in.
Beam	65 ft. 0 in.
Depth	14 ft. 0 in.
Draft, light	5 ft. 0 in.
Draft, loaded at 600-ton payload (normally includes a full deck area of vehicle loading)	6 ft. 0 in.
Draft, loaded at 2, 300-ton payload	11 ft. 0 in.
Power, quadruple screws	2, 400 hp.
Speed (approximate) at 600-ton payload	14 k.

Proposed Military Characteristics

1. The vessel shall be capable of self-delivery across the ocean under its own power.

2. The landing draft shall be 5 feet 0 inches (light ship) at a point 150 feet from shore, and shall taper to 0 feet at the shoreline.

3. The loading and unloading rate shall be comparable in speed to that of vehicles rolling on or off ferryboats.

4. The construction shall be austere with the emphasis on form for speed.

5. The deck area shall be clear throughout for maximum loading accommodation.

6. The vessel shall accommodate either five 85-ton atomic guns, thirty 35-ton tanks, or seven BARCs; or shall have the equivalent deck area to accommodate any piece of mobile equipment necessary to support a major military operation.

7. The steering shall be accomplished by propellers only (precluding the use of rudders, steering gear, or steering wheel) for beaching, for retracting, and for broaching prevention.

8. Loading and unloading shall be accomplished from the stern in order to have a better ramp and hull form.

9. The control shall be from the flying bridge amidships.

10. A transition from broad beam to an underwater form suitable for high speed shall be incorporated.

11. The propellers shall be located at amidships with an outboard angle for handling the vessel as required under any condition of operation and shall be provided with a free flow of water.

12. Blind spots shall be reduced to a minimum to enable deck cargo in the form of tanks and guns to provide firepower in an emergency.

13. A crew of 15 men shall be quartered below deck.

14. There shall be accommodations below deck for vehicle drivers.

15. The vessel shall be equipped for ship-to-shore radiotelephone.

16. Air transportability shall not be required.

17. The vessel shall have built-in characteristics which will permit operation in water not subject to freezing at air temperatures from -40° F to +125° F (plus induced solar radiation), and will permit out-of-water storage from -80° F to +160° F, and in-water storage from +30° F to +160° F.

18. Radio interference components shall be suppressed as required, in accordance with U. S. Army practice.

19. The vessel shall be constructed of readily available nonstrategic domestic materials to the greatest extent practicable. Materials and components shall be suitable for their purposes.

APPENDIX II

R & D TASK CARD	TYPE OF REPORT: Termination	REPORT CONTROL SYMBOL: CSCRD-1(R1)

1. Task TITLE	2. SECURITY OF Task	3. PROJECT NO.
Lighter, Beach Discharge, Deck Cargo, Diesel, Steel, 300 Ft (U)	U	9R57-02-018
	4. Task Nr. 9R57-02-018-01	5. REPORT DATE 15 Jul 60

6. BASIC FIELD OR SUBJECT	7. SUB FIELD OR SUBJECT SUB GROUP	7A. TECH. OBJ.
Marine Craft	Barges, Boats, Lighters & Vessels	SO-5

8. COGNIZANT AGENCY	12. CONTRACTOR AND/OR LABORATORY	CONTRACT/W. O. NO.
Transportation Corps		
9. DIRECTING AGENCY: USATRECOM		
10. REQUESTING AGENCY: Transportation Corps		

11. PARTICIPATION AND/OR COORDINATION	13. RELATED PROJECTS	17. EST. COMPLETION DATES
Dept. of the Navy (P)		RES. Completed
		DEV. Completed
		TEST Completed
		OP. EVAL. Completed

14. DATE APPROVED	15. PRIORITY	16. Budget code:
26 March 1953	1-C	4.10

18. FY.	FISCAL ESTIMATES
T	$ 993M

19. REPLACED PROJECT CARD AND PROJECT STATUS

Completed task. Replaces task card dated 31 Dec 59.

20. REQUIREMENT AND/OR JUSTIFICATION

A TC requirement exists for a shallow draft type lighter to transport large quantities of mobile and/or outsized equipment to a beach for resupply in ship-to-shore operations. Large quantities and varieties of mobile and cumbersome equipment, such as heavy tanks, artillery and construction equipment, are required to support a major military operation and demand expeditious marine transportation to an extent far surpassing the capacity of existing available craft. Existing craft are incapable of performing the mission, in many cases, because of poor landing conditions and/or capacity limitations. CDOG ref: Par 1635b(2).

21. BRIEF OF Task AND OBJECTIVE

a. Brief:

(1) To fulfill this requirement, it was proposed to develop and construct a prototype of a new marine lighter, capable of large capacity, high speed, rapid loading and discharge of all types of mobile equipment, easily maneuverable, and operable in shallow waters. Technical characteristics of the lighter are approximately: overall length 300'; beam, 65'; draft, light, 5'0".

22. OASD (R & D)	BN.	CN.	C.	X.	I.	E.

DD FORM 1 APR 58 613 Action approved, TCTC Mtg 130, 22 Sep 60 PAGE 1 OF 4 PAGES

REPLACES DD FORM 613, 1 JAN 55.

RDT & E PROJECT CARD CONTINUATION	REPORT DATE 15 Jul 60	PROJECT NO. 9R57-02-018

(2) The immediate objective was to design and develop a 300-foot beach discharge lighter. The ultimate objective is to type classify the item as Standard Army equipment.

b. Approach: Not applicable. See Background history, par 21e.

c. Tasks: None.

d. Other information:

(1) Scientific research: Not applicable.

(2) Standardization item: Not applicable.

(3) Engineering test: Not applicable.

(4) Operational availability date: Task completed. Item type classified.

(5) Same or related items: None.

(6) Specific review points: Not applicable.

(7) Other funds: PEM,A $2,660M.

(8) BuShips provided technical assistance and facilities in construction of item.

e. Background history and progress: Task was initiated in 1953 to design and develop a shallow draft type lighter to transport large quantities of mobile and/or outsized equipment to a beach for resupply in ship-to-shore operations. A model was built and used to experiment with speed, power, maneuverability, and various methods of propulsion. A design contract was awarded and completed. A contract was awarded for the design and construction of two vertical axis propellers for the lighter. Funds were transferred to BuShips for construction of the lighter. A contract was awarded for construction of the beach lighter. The keel was laid on 7 December 1956. Vessel was launched 28 September 1957 and christened "Lt. Col. John U. D. Page." MARK 14 gyro compass, propeller lube oil manifolds and additional berthing installed; also, minor modifications accomplished at San Francisco in January 1959. BDL left for Canal Zone February 1959, arrived at Fort Eustis April 1959. Detailed three weeks in Canal Zone for modifications and repairs to ballast tank bulkheads. Several cracks appeared in bulkheads enroute to Canal Zone. Beaching, loading, and off-loading tests conducted at Fort Eustis. During July, government and contractor responsible repairs and modifications, including installation of hydraulic tensioning rams, were accomplished. In August, marriage tests were successfully conducted with the "Comet" in Chesapeake Bay. During September, the "Page" made the trip to France and took

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RDT & E PROJECT CARD CONTINUATION	REPORT DATE	PROJECT NO.
	15 Jul 60	9R57-02-018

part in the NODEX operations in October. Successful marriage operations were conducted with the "Comet" at NODEX. The BDL left France on 30 October 1959 for Fort Eustis stopping at Azores for refueling and minor bulkhead repairs, arriving at Fort Eustis 6 December 1959. BDL turned over to TTC 3 March 1960 for user test. TRECOM has conducted standardization trials using Rotor "A" motion versus sinusoidal motion as a part of the engineering test. Type classification as STD-A is recommended by TCTC item 3518/130(ref 21g(10)). This task is being terminated.

f. __Future plans__: None.

g. __References__:

(1) Transportation Board Item 164/2, Meeting 53, held 8 January 1953, Requirement for a Vehicle Transporter; recommending initation of a development project.

(2) TCTC Item 995, Meeting 78, held 29 January 1953, Development Project 9-57-07-001, Lighter, Beach Discharge, Deck Cargo, Diesel, Steel, 300 Ft; military characteristics of item and initation of project approved by the Technical Committee 29 January 1953 and by General Staff 26 March 1953.

(3) Letter, OCOFT to President, Transportation Board, subject: "Assignment of Development Project 9-57-07-001, Lighter, Beach Discharge, Deck Cargo, Steel, 300 Ft," file TCRRD-TC 400.112, dated 4 May 1953.

(4) DF, Comment 2, from DEPLOG thru Comptroller, to CofT, subject: "Materiel Program, Schedule of Commitments, FY 1955," file LOG/G2 16632, dated 21 April 1955; approving $400,000 for vertical axis propellers.

(5) DF, Comment 2, from DEPLOG thru Comptroller, to CofT, subject: "Materiel Program, Schedule of Commitments, Fiscal Year 1955 - Subproject 4062," file LOG/G2 21977, dated 27 May 1955; approving $2,100,000 for construction of prototype.

(6) MIPR TRADCOM 55-3, dated May 1955, with 10 amendments, transferring $2,660,000 to BuShips, Department of the Navy, for construction of protytype lighter.

(7) TCTC Item 1725, Meeting 102, held 22 March 1956, Development Project 9-57-03-000, Marine Craft; initiation of project and consolidation of projects approved by the Technical Committee on 22 March 1956 and by Ch/R&D, OCS on 19 November 1956.

(8) TCTC Record and Information Item 2037, Meeting 108, held 7 March 1957, recording establishment of Subtask 109M, Project 9-57-03-000 (subsequently redesignated as Task 109M) and supersession of Project 9-57-07-001.

DD FORM 1 FEB 60 613c REPLACES DD FORM 613-1, WHICH IS OBSOLETE. PAGE 3 OF 4 PAGES

RDT & E PROJECT CARD CONTINUATION	REPORT DATE 15 Jul 60	Task NO. 9R57-02-018

(9) TCTC Record and Information Item 3313, Meeting 126, held 17 December 1959, Renumbering of Transportation Corps Research and Development Projects and Tasks; Changes in Titles; redesignating Task 109M as Task 9R57-02-018-01.

(10) TCTC Item 3518, Meeting 130, scheduled for 22 September 1960, LIGHTER, BEACH DISCHARGE: deck cargo, diesel, steel, 338 ft, design 5002; revised military characteristics and type classification as STD-A. Item withdrawn.

(11) TCTC Coordinating Subcommittee Item 888, Meeting 46, held 15 July 1960, Task 9R57-02-018-01, Lighter, Beach Discharge, Deck Cargo, Diesel, Steel, 300 Ft (U); completion; approved for referral to TC Technical Committee.

DD FORM 1 FEB 60 613c REPLACES DD FORM 613-1, WHICH IS OBSOLETE. PAGE 4 OF 4 PAGES

RESEARCH AND DEVELOPMENT PROJECT CARD (NEW PROJECTS) | **2. SEC.** U | **3. PROJ. NO.** 9-57-07-001

1. PROJECT TITLE Lighter, Beach Discharge, Deck Cargo, Diesel, Steel, 300 Ft. LIGHTER BEACH DECK

4. INDEX NO. Item 995/78

5. REPORT DATE 15 Jan 53

6. BASIC FIELD OR SUBJECT Marine Craft

7. SUB FIELD OR SUBJECT SUB GROUP Landing

TECH OBJ: SO-5

8. COGNIZANT AGENCY Transportation Corps

9. DIRECTING AGENCY Transportation Research & Development Station

10. REQUESTING AGENCY Office, Chief of Transportation

11. PARTICIPATION AND/OR COORDINATION

12. CONTRACTOR AND/OR LABORATORY

CONTRACT/W. O. NO.

13. RELATED PROJECTS

14. DATE APPROVED

15. PRIORITY 1-C

16. MAJOR CAT.

17. EST. COMPL. DATES	
RES.	
DEV.	Jun 54
TEST	Dec 54
OP EVAL	Jun 55

F Y	**18. FISCAL EST'S**
53	$ 1,400M
54	35M
T	1,480M

19.

20. REQUIREMENT AND/OR JUSTIFICATION A Transportation Corps requirement exists for a shallow draft type lighter to transport large quantities of mobile and/or outsized equipment to a beach for resupply in ship-to-shore operations. Large quantities and varieties of mobile and cumbersome equipment, such as heavy tanks, artillery and construction equipment, are required to support a major military operation and demand expeditious marine transportation to an extent far surpassing the capacity of existing available craft. Existing craft are incapable of performing the mission, in many cases, because of poor landing conditions and/or capacity limitations.

21. BRIEF OF PROJECT AND OBJECTIVE

a. Brief:

(1) To fulfill this requirement, it is proposed to develop and construct a prototype of a new marine lighter, which will be capable of large capacity, high speed, rapid loading and discharge of all types of mobile equipment, easily maneuverable, and operable in shallow waters. The long range objective is the type classification of the item for the Transportation Corps Marine Fleet.

(2) Technical characteristics: On the basis of current studies, planned technical characteristics of the lighter are approximately: overall length, 300'; beam, 65'; draft, light, 5'0".

(3) Military characteristics:

(a) The lighter shall be capable of transporting mobile and outsized equipment to the beach.

(b) The lighter shall be capable of loading and discharging mobile equipment and cargo on a beach by means of a ramp.

(c) The lighter shall have a propulsion system that will allow high maneuverability and rapid retraction from a beach.

22. RDB | **SN.** | **FC.** | | **X.** | **I.** | **C.**

RDB FORM 1A 1 APR 1947

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Army, Fort Eustis, Va. 1953-M-3726b

(d) The lighter shall have a cargo capacity of not less than 600 long tons for any landing condition and a maximum cargo capacity of not less than 1000 long tons.

(e) The lighter shall have a cruising speed of not less than 14 knots with 600 long tons of cargo.

(f) The lighter shall have a deck area of approximately 15,000 sq. ft.

(g) Accommodations shall be provided for a suitable crew.

(h) The lighter shall be equipped with navigational radar and ship-to-shore radiotelephone.

(i) Transportability: Land transportability and air transportability of the item in whole or in part are not required.

(j) The lighter in a ballasted condition, shall be capable of self-delivery overseas.

(k) Temperature limitations: The item is intended for use in temperate zones. Neither operation nor storage in waters subject to freezing is contemplated. The item shall be designed to have the inherent capability of acceptable performance within an air temperature range extending from +125° F. (minimum exposure of 4 hours with full impact of solar radiation, 360 BTU/Ft Sq/Hr) to -20° F. (minimum exposure of 3 days without benefit of solar radiation). It must be susceptible of safe in-water storage and transportation without permanent impairment of its capabilities from the effects of temperature from +160° F., for periods as long as 4 hours per day, to -20° F., for periods of at least 3-days' duration. Out-of-water storage is not contemplated.

(l) Radio interference suppression: Components shall be suppressed as required in accordance with U.S. Army practices.

(m) Quantity production: The design shall insure the maximum practicable interchangeability of parts and be suitable for production in the quantities for which there are potential requirements.

(n) Materials: The item shall be constructed of readily available nonstrategic and noncritical materials to the extent practicable.

b. Approach:

(1) It is proposed to investigate and to determine the most practicable design of craft that will be suitable for transporting outsize cargo and mobile equipment for beach discharge.

(2) Scale models will be tested to determine the most suitable design including hull form, propulsion, steering, retraction systems, etc.

(3) One experimental model will be procured and subjected to engineering and service tests to determine the capabilities of the item to meet requirements and its suitability for Transportation Corps operations.

(4) Upon completion of engineering and service tests and any necessary modifications an appropriate report will be submitted including recommendations for the type classification of the item.

c. Subtasks: There are no anticipated important subsidiary tasks in connection with this project.

d. Other information:

(1) Reference:

(a) Transportation Board Item TB 164/2, Meeting 53, held 8 January 1953, Requirement for a Vehicle Transporter; recommending initiation of a development project.

(2) Services and agencies other than the Transportation Corps interested in this project are: None

(3) Priority justification: This project is intended to develop equipment essential to the successful accomplishment of the mission of the Transportation Corps in the transportation of cumbersome equipment from ship to the beach and is assigned D/A priority 1-C.

(4) Estimated costs: Obligations under this project including the cost of the prototype will be charged against Transportation Corps Research and Development funds, Fiscal Project 1320, Supply and maintenance operations. Obligations are estimated as follows:

APPENDIX III

300' BEACH DISCHARGE LIGHTER

Preliminary Study Report
for Phase I

Prepared by

Bethlehem Steel Company
Shipbuilding Division
Quincy, Massachussetts

TABLE OF CONTENTS

I. INTRODUCTION

This report is intended to outline the procedure undertaken by the Design Agent to fulfill the contract for preparation of preliminary technical studies in connection with the proposed Beach Discharge Lighter for the Army Transportation Research and Development Command.

In advance of the participation of the Design Agent in the development of the Beach Lighter concept, the feasibility of such a craft and its general requirements had been established by Tradcom. Using model test data from Stevens Institute and data obtained from the performance of a 25 foot scale model run under varying conditions in the James River, together with comment and advice of the Board of Consultants, a basic design was established at Tradcom for a vessel 300' by 65' employing angular thrust propulsion and fitted with a stern ramp for cargo loading and discharge.

Preliminary technical data, sketches and other information for this basic concept were given to the Design Agent for review.

In addition, two alternate proposals were also presented for study. One proposal developed at Tradcom utilizes vertical axis propulsion at the stern and a bow ramp. The other proposal developed at Bureau of Ships also utilizes vertical axis propulsion but locates the propeller units forward and the ramp at the after end.

Comparative data for the three above mentioned concepts, together with a fourth proposal utilizing tunnel stern propulsion, are outlined in this report.

In collaboration with Tradcom representatives, investigations of performance in smooth water and in waves have been conducted at the Experimental Towing Tank at Stevens Institute using models of the angular thrust and the bow ramp vertical axis design.

Five additional proposals have received some study by the Design Agent and have been reviewed by Tradcom representatives. Although further consideration of these five proposals appears undesirable, pertinent comment is included in the evaluation section herein and arrangement plans have been distributed for information.

II. FOUR DESIGN CONCEPTS

A. DESCRIPTION AND CHARACTERISTICS

Concept No. 1
Angular Thrust Propulsion

The Angular Thrust concept proposes a self-propelled, flush deck lighter. See Figure 1.

The hull is proposed to be of ferryboat type to give a large deck area for roll on, roll off loading of vehicles. Access to the deck is by a stern ramp. The bow of the vessel will be of normal ship shape form with a short forecastle.

Steering and maneuvering is to be accomplished by angular thrust propellers, two at each side, rudders aft of the propellers and retractable rudders aft for ocean voyages.

Dimensions and principal characteristics are tabulated on Page 3

Concept No. 2
Vertical Axis Propulsion, Bow Ramp

This design concept proposes the use of a pair of vertical axis propellers aft for both propulsion and steering. See Figure 2.

The hull form aft embodies a flat run to accommodate the vertical axis propellers. The bow lines are being developed to provide required space for the ramp, minimize pounding and to obtain satisfactory resistance in still water.

It is proposed to provide a cantilevered type wheelhouse, as indicated, to allow maximum usable deck area for cargo stowage.

Dimensions and principal characteristics are tabulated on Page 3

Concept No. 3
Vertical Axis Propulsion, Stern Ramp
(Bureau of Ships Proposal)

This concept proposes a stern ramp design and the use of a pair of vertical axis propellers located about 1/4 length from the bow for both propulsion and steering as indicated in Figure 3.

The hull form embodies a relatively fine bow with a short forecastle.

Dimensions and principal characteristics are tabulated on Page 3

Concept No. 4
Tunnel Stern Propulsion with
Directional Propellers

This concept proposes a hull form similar to No. 2 except that the stern will incorporate tunnels for twin screw propulsion. Steering will be by conventional rudders.

For side thrust to resist broaching and for beach retracting ability, directional propellers are fitted at each stern corner, designed to hinge up for ocean voyages.

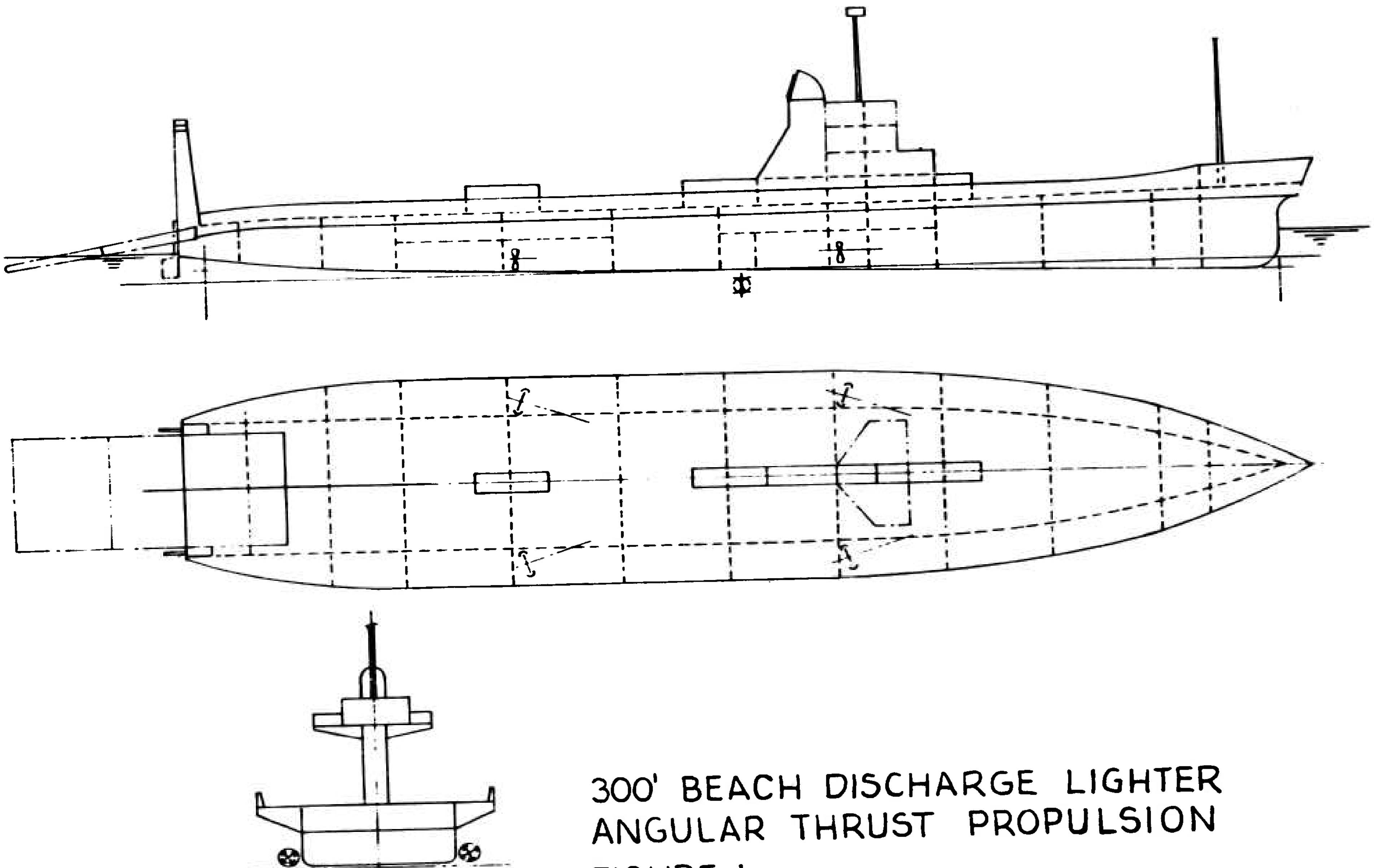
Deck arrangement will be similar to Concept No. 2 and a bow ramp will be employed. See Figure 4.

Dimensions and principal characteristics are tabulated below.

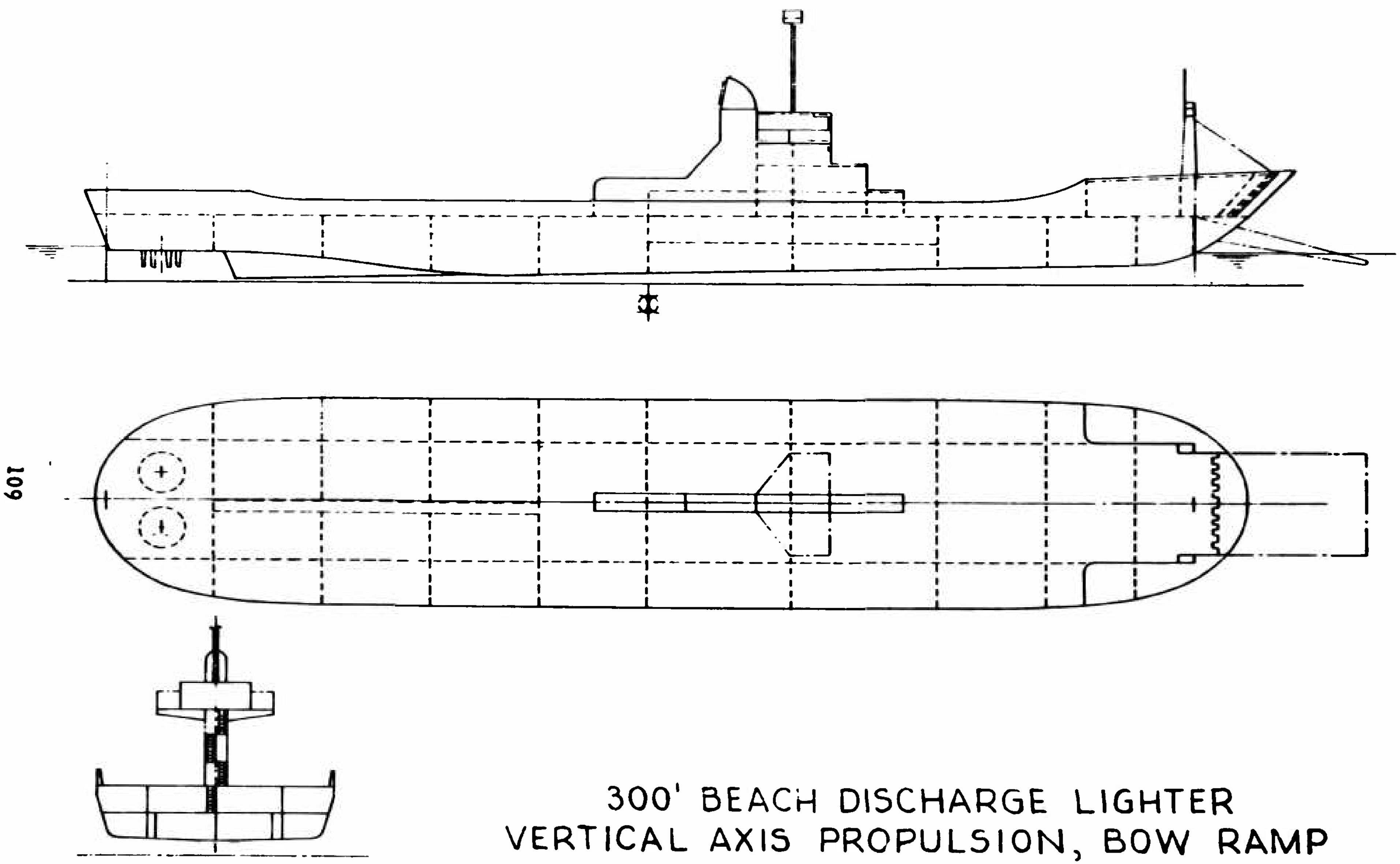
Dimensions and Characteristics

	1 Angular Thrust	2 Vert. Axis Bow Ramp	3 Vert. Axis Stern Ramp	4 Tunnel Stern
Length, overall, about	319'-0"	331'-6"	330'-3"	331'-6"
Length, B.P.	300'-0"	300'-0"	300'-0"	300'-0"
Breadth, mld. at deck	65'-0"	65'-0"	65'-0"	65'-0"
Breadth, mld. ℄ at landing W.L.	42'-0"	61'-0"	53'-0"	61'-0"
Depth, main deck, ℄	19'-6"	18'-0"	21'-0"	18'-0"
Draft, landing, above keel	7'-9"	6'-6"	8'-7"	6'-6"
Displacement, landing	2063	2016	1920	2016
Block coefficient	.731	.593	.491	.593
Prismatic coefficient	.735	.650	.534	.650
Draft, ocean, above keel, ℄		10'-9"	11'-6"	10'-9"
Displacement, ocean	2580	2590	2900	2590
Horsepower, normal	3200	2000*	2000*	2000
Est. horsepower at 14 K. trial speed	2230	2580	4600	2720
Complement - officers, crew, drivers	6-24-202	6-24-204		6-24-204
Useful deck area	14,600	17,800	12,500	17,800

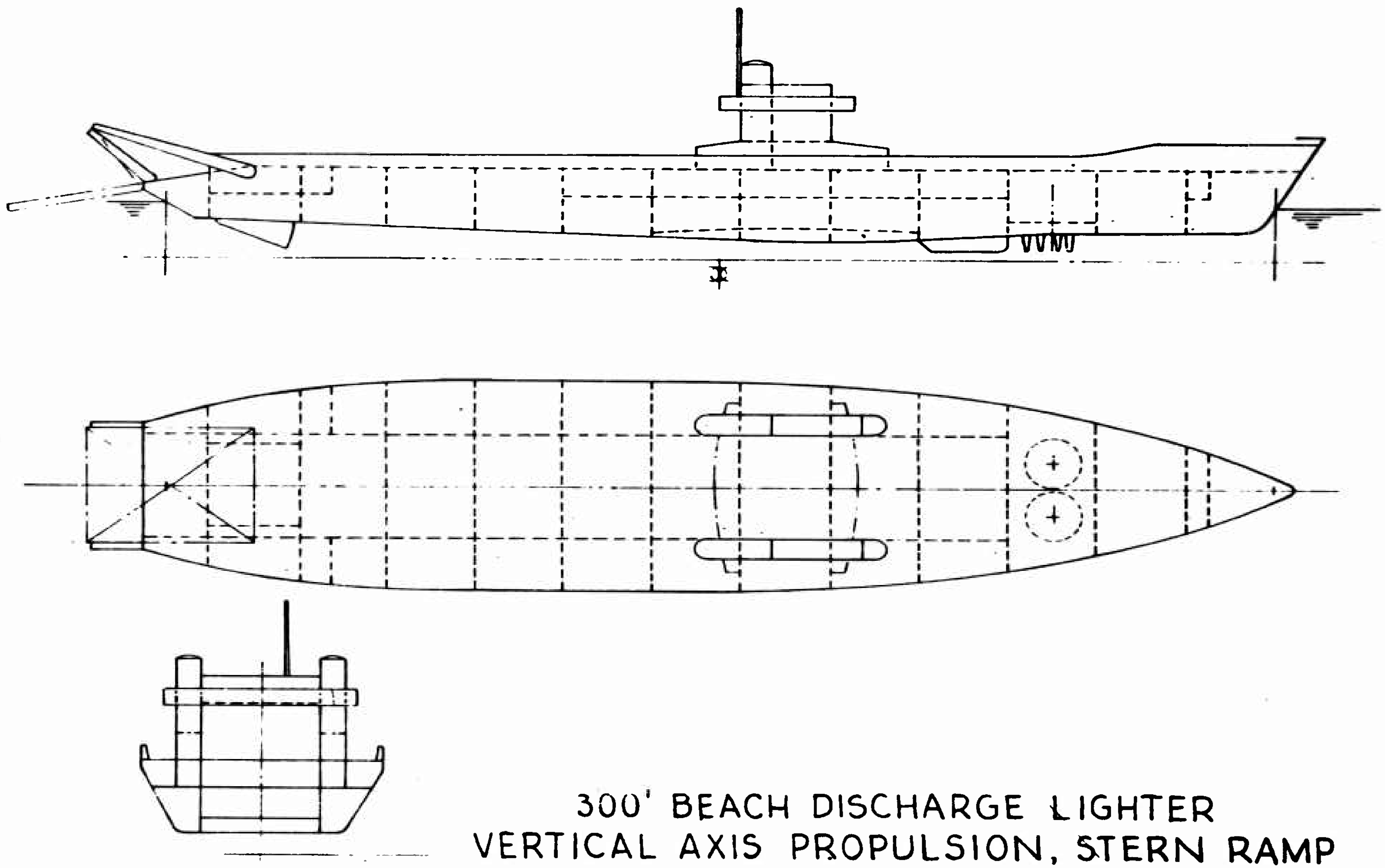
* Based on the existing vertical axis units installed in Army Towboat LTI 2194, two units at 1000 HP.



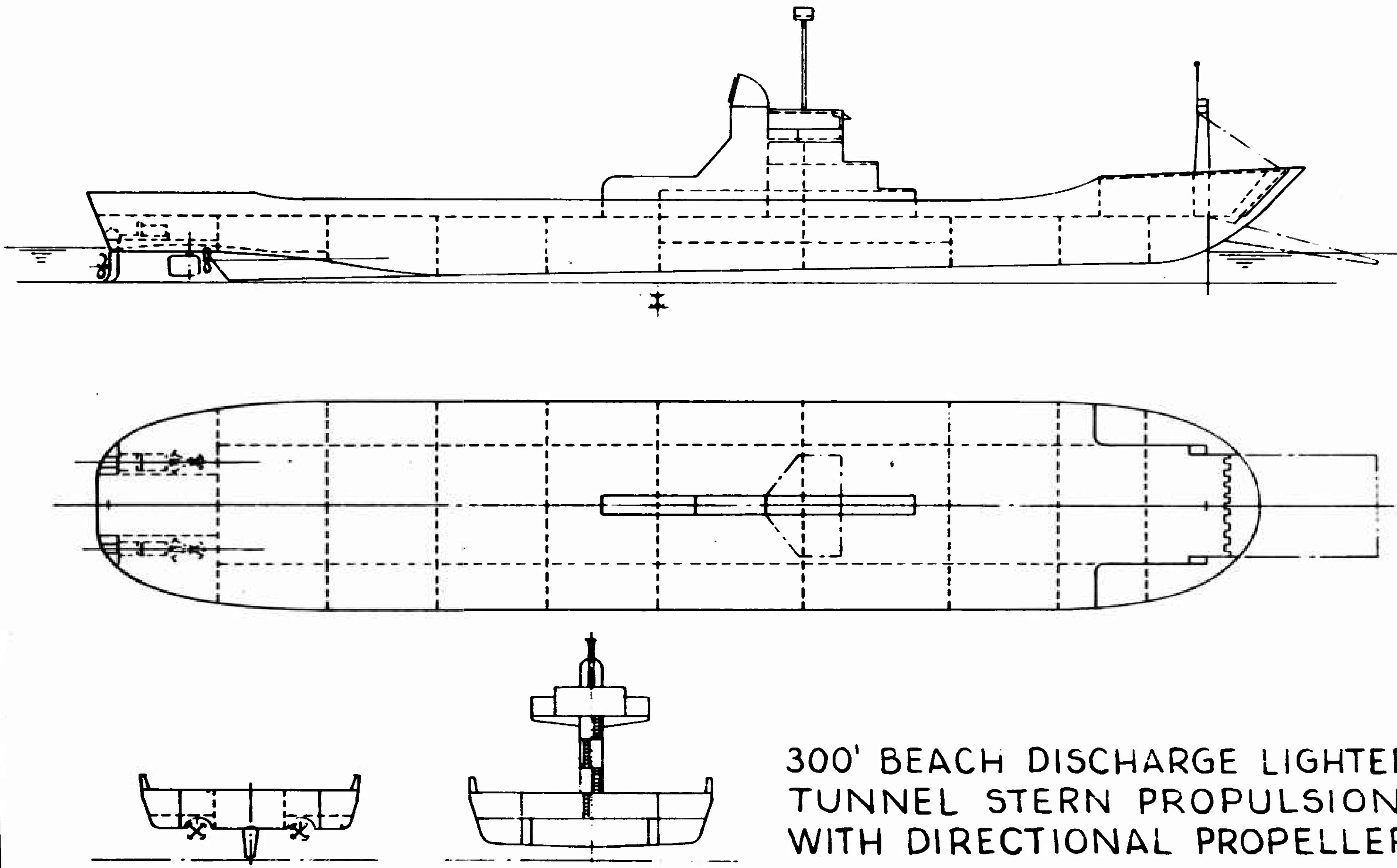
300' BEACH DISCHARGE LIGHTER
ANGULAR THRUST PROPULSION
FIGURE 1



300' BEACH DISCHARGE LIGHTER
VERTICAL AXIS PROPULSION, BOW RAMP
FIGURE 2



300' BEACH DISCHARGE LIGHTER
VERTICAL AXIS PROPULSION, STERN RAMP
FIGURE 3



300' BEACH DISCHARGE LIGHTER
TUNNEL STERN PROPULSION
WITH DIRECTIONAL PROPELLERS
FIGURE 4

B. WEIGHTS, DISPLACEMENT, DRAFTS

	1 Angular Thrust	2 Vert.axis bow ramp	3 Vert.axis stern ramp	4 Tunnel stern
Hull Steel	923	923		923
Superstructure Steel	35	32	BuShips	32
Ramp Structure	50	39	Design	39
Total Steel	1008	994	&	994
Outfit	151	151	Weights	151
Machinery	125	151		125
Ship No Margin	1284	1296		1270
Margin	26	24		25
Light Ship	1310	1320	1320	1295
Landing Condition				
Fuel Oil	90	50		60
Lub. Oil	10	5		10
Fresh Water	30	22		30
Crew and Effects	20	18		20
Stores	3	1		1
Cargo	600	600		600
Total Deadweight	753	696	600	721
Displacement	2063	2016	1920	2016
Drafts, ℄, Abv. Keel	7'-9"	6'-6"	8'-7"	6'-6"
Ocean Condition				
Fuel Oil	172	172		172
Lub. Oil	11	11		25
Fresh Water	83	83		94
Crew and Effects	3	3		3
Stores	1	1		1
Cargo	1000	1000		1000
Ballast				
Total Deadweight	1270	1270	1580	1295
Displacement	2580	2590	2900	2590
Drafts		10'-9"	11'-6"	10'-9"

The light ship weight figures for the vertical axis propulsion, bow ramp design are from a detailed weight estimate. These figures have been used as a basis for proportional figures for the other proposals.

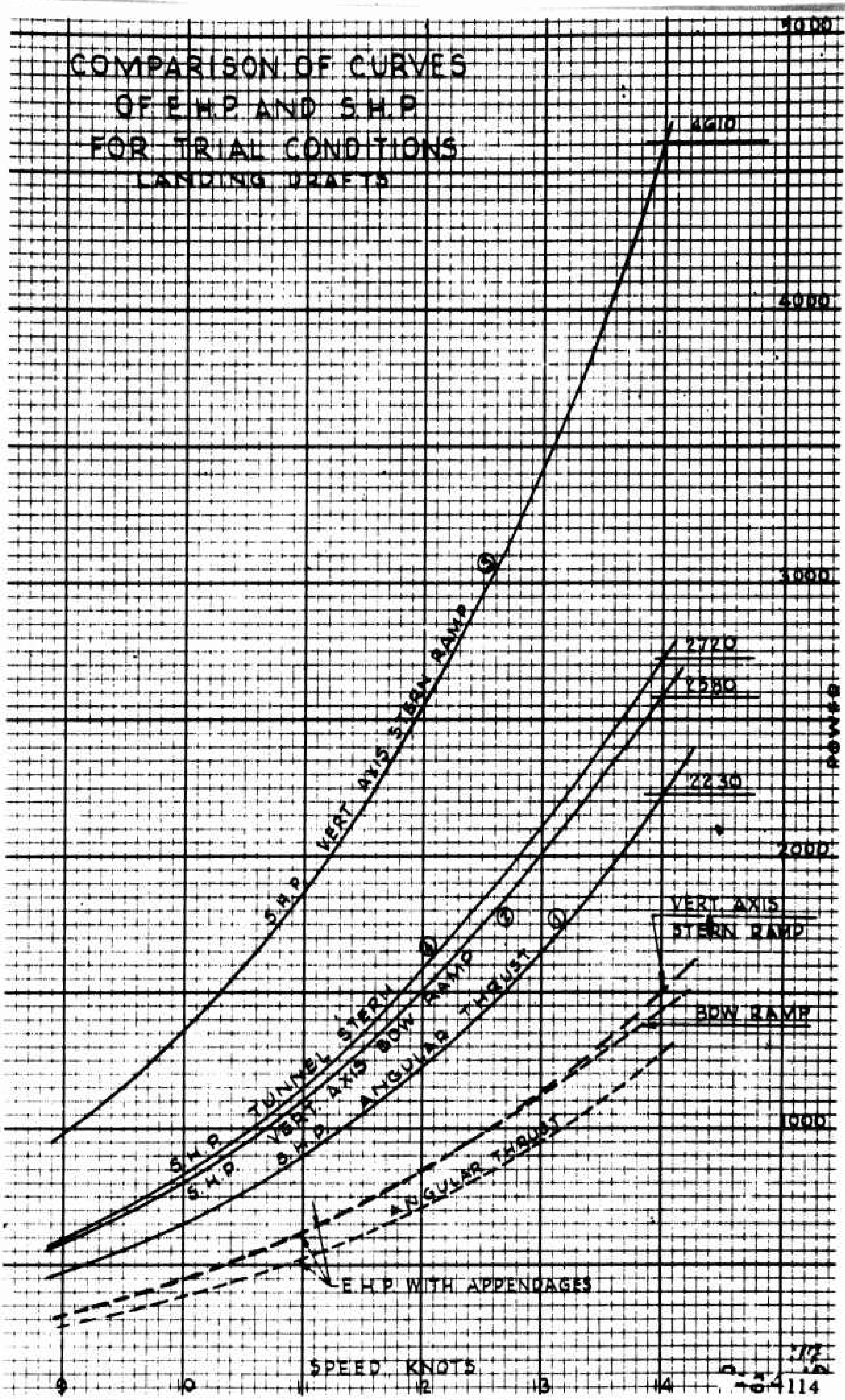
No weight details are available for vertical axis, stern ramp (BuShips) proposal.

The deadweight figures have been derived from preliminary Tradcom information.

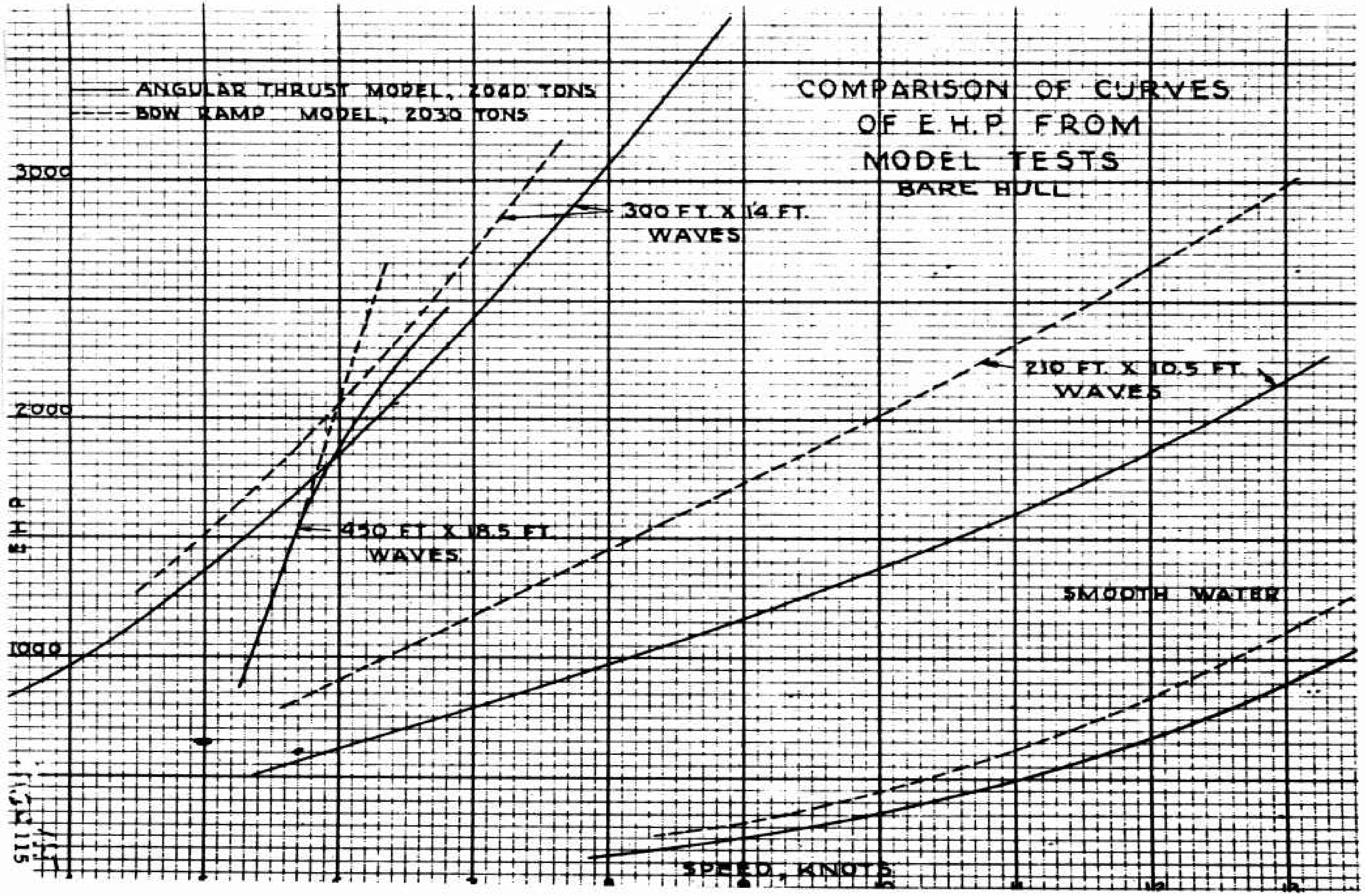
C. MILITARY CHARACTERISTICS

	1 Angular thrust	2 Vert.axis bow ramp	3 Vert.axis stern ramp	4 Tunnel stern
a. Capable of transporting mobile & out-sized equipment to the beach.	✓	✓	✓	✓
b. Capable of loading & discharging mobile equipment & cargo on a beach, with ramp.	✓	✓	✓	✓
c. Have propulsion system allowing high maneuverability, rapid retraction from beach.	See Sects. IIF,G	See Sects. II,F,G	See Sects. II,F,G	See Sects. II,F,G
d. Have cargo capacity of 600 tons in landing condition, 1000 tons maximum.	✓	✓	✓	✓
e. Have cruising speed of 14K with 600 tons.	See Sect.IID	See Sect.IID	See Sect.IID	See Sect.IID
f. Have deck area of 15,000 sq.ft.	14600	17800	12500	17800
g. Have accommodations for crew.	✓	✓	✓	✓
h. Have navigational radar and ship-to-shore radio-telephone.	✓	✓	✓	✓
i. Land or air transportability not required.	✓	✓	✓	✓
j. Capable of self-delivery overseas.	✓	✓	✓	✓
k. Operation at extreme temperatures not req'd.	✓	✓	✓	✓
l. Have radio interference suppression.	✓	✓	✓	✓
m. Have interchangeable parts, be suitable for mass production.	✓	✓	✓	✓
n. Material to be non-strategic & non-critical.	✓	✓	✓	✓

✓ = Satisfies Military Characteristics



COMPARISON OF CURVES
OF E.H.P. AND S.H.P.
FOR TRIAL CONDITIONS
LANDING DRAFTS
4610
2720
2580
2230
S.H.P. VERT. AXIS STERN RAMP
S.H.P. TUNNEL STERN
S.H.P. VERT. AXIS BOW RAMP
S.H.P. ANGULAR THRUST
VERT. AXIS
STERN RAMP
BOW RAMP
ANGULAR THRUST
E.H.P. WITH APPENDAGES
SPEED, KNOTS
POWER
5000
4000
3000
2000
1000
9
10
11
12
13
14



COMPARISON OF CURVES
OF E.H.P. FROM
MODEL TESTS
BARE HULL
ANGULAR THRUST MODEL, 2040 TONS
BOW RAMP MODEL, 2030 TONS
300 FT. X 14 FT.
WAVES
450 FT. X 18.5 FT.
WAVES
210 FT. X 10.5 FT.
WAVES
SMOOTH WATER
3000
2000
1000
E.H.P.
SPEED, KNOTS

115

SUMMARY OF BASIS USED IN ESTABLISHING

ESTIMATED TRIAL PERFORMANCE

1. Angular Thrust Propulsion

EHP from model test, bare hull, increased by 6% for resistance of shaft bossings; thrust deduction = .10; wake fraction = .10; effect of angularity of shafts, 13% reduction in thrust, based on simplified theoretical calculation; propellers are 3 blade Troost B3.50 type, 5'-0" diameter aft with pitch ratio = 1.36, 6'-6" diameter forward with pitch ratio = .78; SHP increased by 1½% to cover gear losses.

2. Vertical Axis Propulsion - Bow Ramp

EHP from model test, bare hull; thrust deduction = .15; wake fraction = .10; vertical axis propellers have 9'-0" orbit diameter, 4'-6" blade length, characteristic curves used are those furnished by Dr. Hans Mueller as applicable to a Rotor "A" propeller; SHP increased by 5% to cover gear losses.

3. Vertical Axis Propulsion - Stern Ramp

EHP from stern ramp model test, bare hull, increased by 25% for resistance of protective skegs and peculiar form needed to accommodate propellers; thrust deduction = .43 based on assumption that such an installation would require 50% more thrust than with propellers aft, this figure arrived at on basis of model tests quoted by Dr. Mueller; wake fraction = 0; same propeller and characteristic curves as used for Bow Ramp, Vertical Axis Propeller estimate; SHP increased by 5% to cover gear losses.

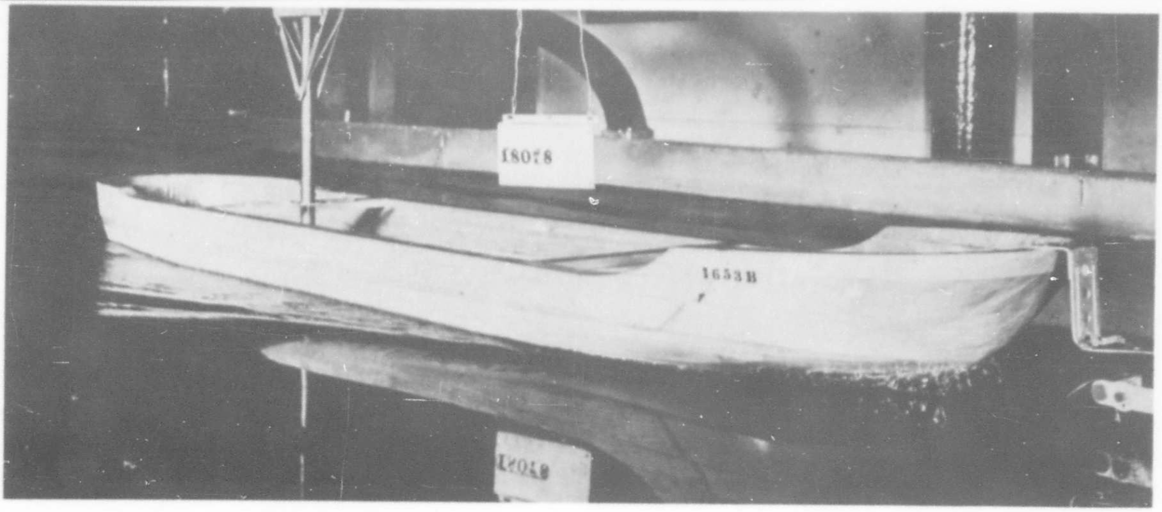
4. Tunnel Stern Propulsion

EHP from model test, bare hull (same as 2); thrust deduction = .25; wake fraction =.20; propellers are 3 blade, 6'-6" diameter, pitch ratio = .75, Troost B3.50 type for which published characteristic curves apply; SHP increased by 1½% to cover gear losses.

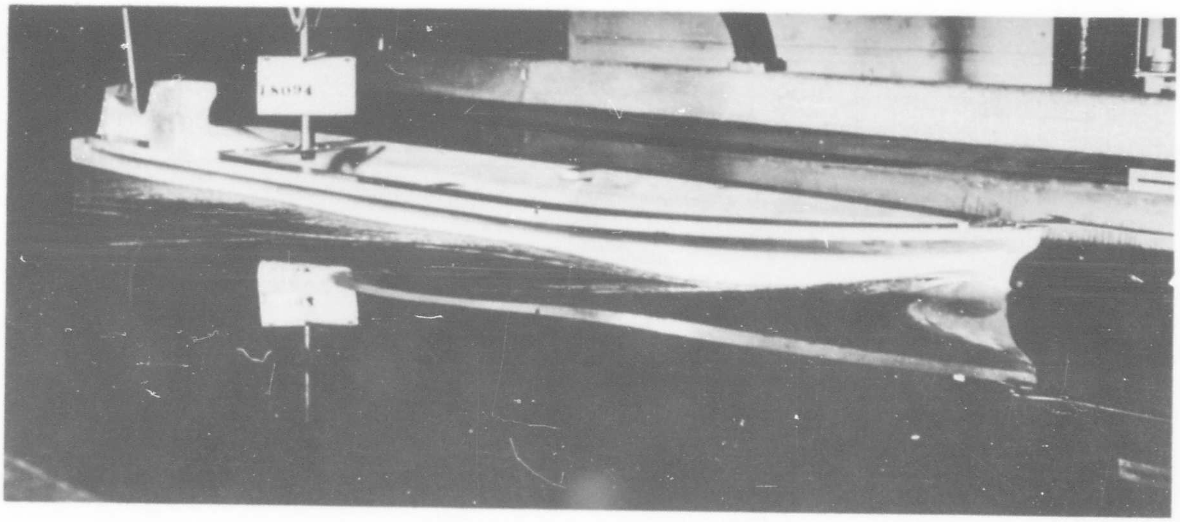
General Notes: It is to be emphasized that the curves given apply to smooth water with a clean bottom, that is, trial conditions. Also, the estimate for the Angular Thrust Propulsion proposed assumes the absence of all air sucking by the propellers and that the flow to the propellers is not adversely influenced by the free surface above and the shaft bossings ahead. Owing to the unusual nature of both stern ramp forms and their propulsion methods, the SHP estimated for these proposals should be considered as quite approximate.

ESTIMATED TRIAL SHP FOR 14 KNOTS TRIAL SPEED

Proposal 1	Proposal 2	Proposal 3	Proposal 4
2230	2580	4600	2720



EXPERIMENTAL TOWING TANK **STEVENS INSTITUTE OF TECHNOLOGY** **HOBOKEN, NEW JERSEY** (Bethlehem Dwg.PR-1888-H20)	300-FT. BEACH LIGHTER (BOW-RAMP DESIGN) TRANSPORTATION RESEARCH & DEV. COMMAND DISPL. = 2030 Tons L.C.G. = - DRAFT = 6.5 Ft.(Mean) V_s = 13.73 Knots TRIM = Des.



EXPERIMENTAL TOWING TANK **STEVENS INSTITUTE OF TECHNOLOGY** **HOBOKEN, NEW JERSEY** (Trans.Res. & Dev. Command Alt."C")	300-Ft. BEACH LIGHTER (SIDE-THRUST DESIGN) TRANSPORTATION RESEARCH & DEV. COMMAND DISPL. = 2040 tons L.C.G. = - DRAFT = 7.75 ft.(mean) V_s = 13.73 knots TRIM = Des.

E. Seaworthiness

ACCELERATIONS AND PITCHING AMPLITUDES AT BOW

Predicted from Model Tests

10 cycle Average at Station No. 0

Stevens ETT Model No. 1653, Side Thrust, 2040 Tons S.W. Displacement

Stevens ETT Model No. 1653B, Bow Ramp, 2030 Tons S.W. Displacement

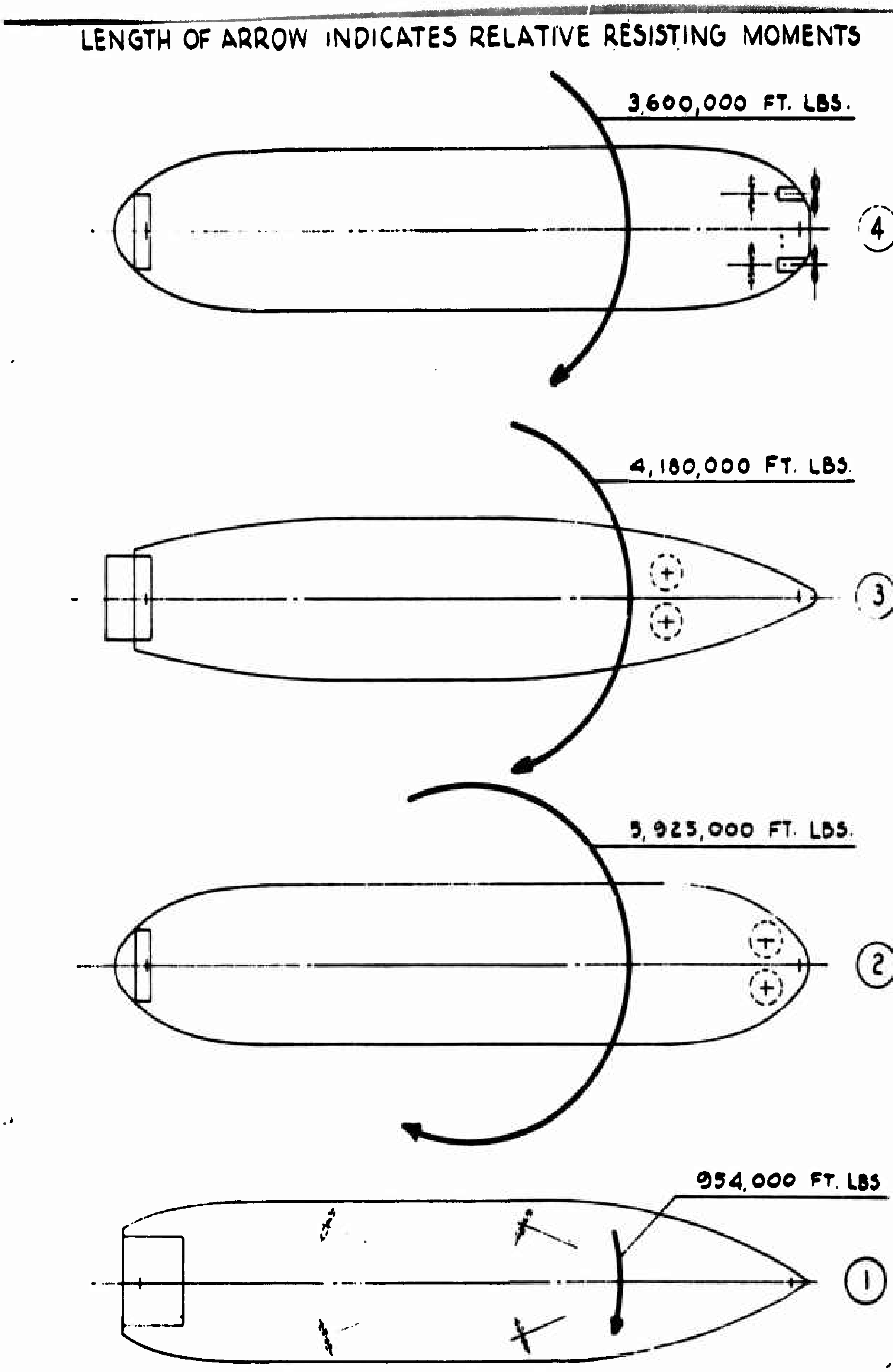
Wave Size Length x Height Ft.	Speed Knots	Acceleration in "g"s Side Thrust Bow Up	Acceleration in "g"s Side Thrust Bow Down	Acceleration in "g"s Bow Ramp Bow Up	Acceleration in "g"s Bow Ramp Bow Down	Total Pitching Amplitude, Ft. Side Thrust	Total Pitching Amplitude, Ft. Bow Ramp	No. of Severe Slams Side Thrust	No. of Severe Slams Bow Ramp
210 x 10.5	6*	0.22	0.18	0.16	0.25	8.5	7.4(?)	0	5
	10	0.20	0.15	0.20	0.26	5.2	5.2	0	6
300 x 14	4	0.37	0.39	0.20	0.43	23.6	13.6	0	10
	6	0.41	0.40	0.36	0.40	19.6	20.2	0	10
450 x 18.5	4	0.34	0.46	0.30	0.31	39.3	36.1	10**	7**
	6	0.36	0.51	0.50	0.35	39.7	43.5	0	0

* This condition is near synchronism between the period of encounter and the models' natural pitching periods, which were determined experimentially to be as follows (full-scale):

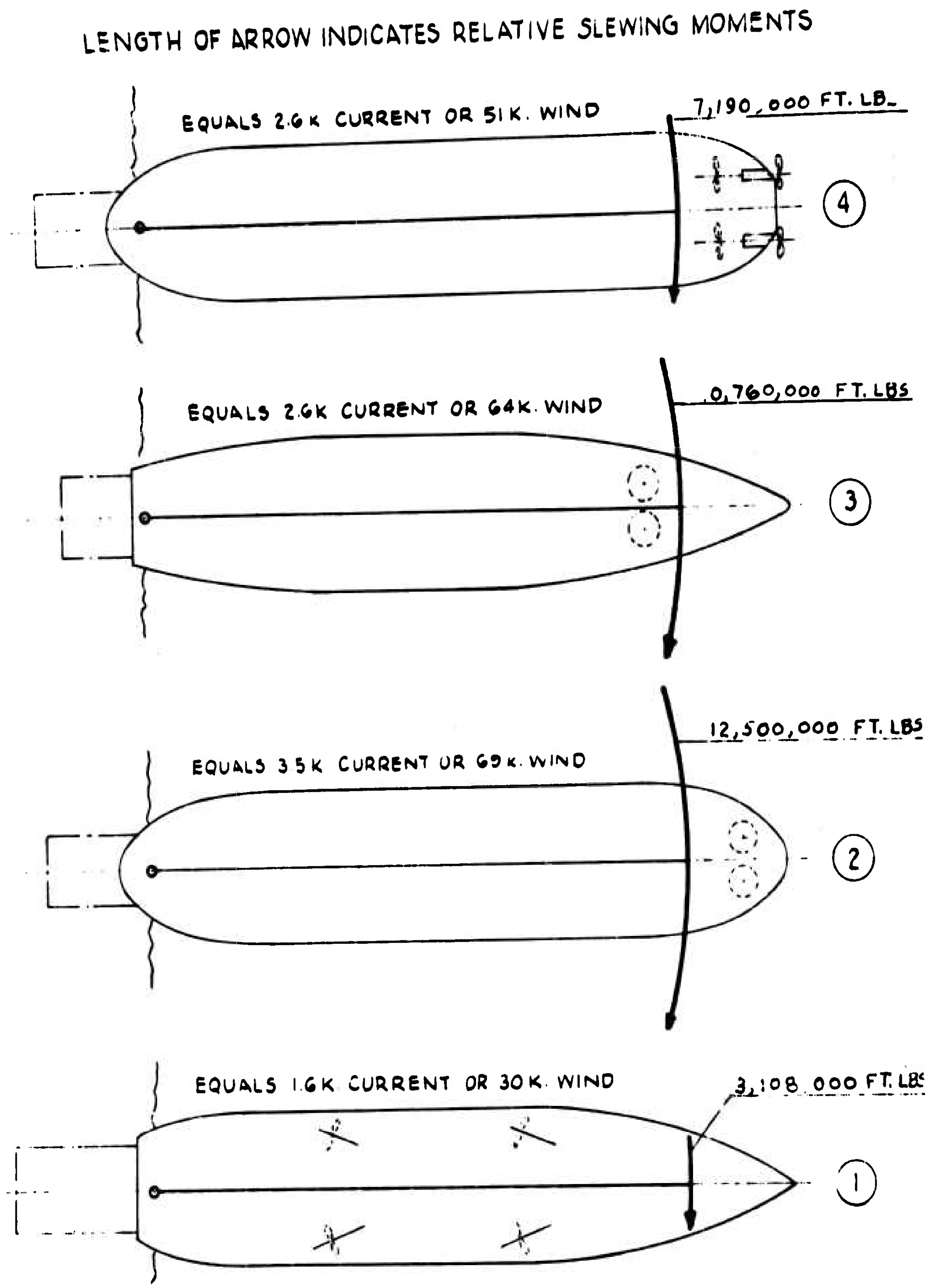
Side thrust design - 4.9 sec.

Bow ramp design - 5.4 sec.

** All of these slams occurred at somewhat less than 1/4 cycle after the bow down position (peak upward acceleration).



ABILITY TO RESIST BROACHING IN WATERBORNE, AT-REST CONDITION



ABILITY TO SLEW-OFF BEACH AND
TO RESIST BROACHING IN BEACHED CONDITIONS

TURNING MOMENTS FOR RESISTING BROACHING IN WATERBORNE, AT-REST CONDITION

Propulsion	No. Units	SHP Per Unit	EFFECTIVE THRUST Per Unit	LEVER to ℄ - ft.	TOTAL MOMENT ft.-lbs.	Basis
Angular Thrust	4	470 (Est.) (1)	8,700	48 Fwd 7 Aft	954,000	Model Test and (1)
Vertical Axis Bow Ramp	2	1000	21,950	135	5,925,000	Tradcom Curve for T.S. Towboat
Vertical Axis Stern Ramp	2	1000	21,950	95	4,180,000	Tradcom Curve for T.S. Towboat
Tunnel Stern with Directional Propellers	2	350	12,000	150	3,600,000	34.5 lbs. Thrust per SHP (2)

(1) From analysis of tests with Stevens model (30° angle forward props., 25° angle aft props.). At RPM appropriate to 9.2 knots free route. Assumes 100% derived effective thrust on all props. Aft prop. ℄ intersects ship ℄ 16 ft. aft of amidships. Props. sucked air at higher RPM.

(2) Average values quoted by Murray and Tregurtha.

TURNING MOMENTS FOR SLEWING IN BEACHED CONDITION

Propulsion	No. Units	SHP Per Unit	EFFECTIVE THRUST Per Unit	LEVER to Fixed Point on Beach-ft.	Total Moment ft.-lbs.	Basis
Angular Thrust	4	470 (Est.)	8,700	123 Fwd 57 Aft	3,108,000	Model Test and (1)
Vertical Axis Bow Ramp	2	1000	21,950	285	12,500,000	Tradcom Curve for T.S. Towboat
Vertical Axis Stern Ramp	2	1000	21,950	245	10,760,000	Tradcom Curve for T.S. Towboat
Tunnel Stern with Directional Propellers	2	350	12,000	300	7,190,000	34.5 lbs. Thrust per SHP (3)

Fixed point on beach assumed at F.P. or A.P.

(1) From analysis of tests with Stevens model (30° angle forward props., 25° angle aft props.). At RPM appropriate to 9.2 knots, free route. Assumes 100% derived effective thrust on all props. Aft prop. ℄ intersects ship ℄ 16 ft. aft of amidships. Props sucked air at higher RPM.

(2) Average valves quoted by Murray and Tregurtha.

G. RETRACTING

The problem of retraction from the beach has been considered in the development of a Hydraulic Beach Retractor, indicated on Sketches A-D included herewith. A plan, PR-1888-H28, is available for details. The mechanism is in the form of two 80-ton hydraulic jacks hinged to the ship at its inshore end, designed to push against wet sand. These are self-retractable for repositioning or for stowing.

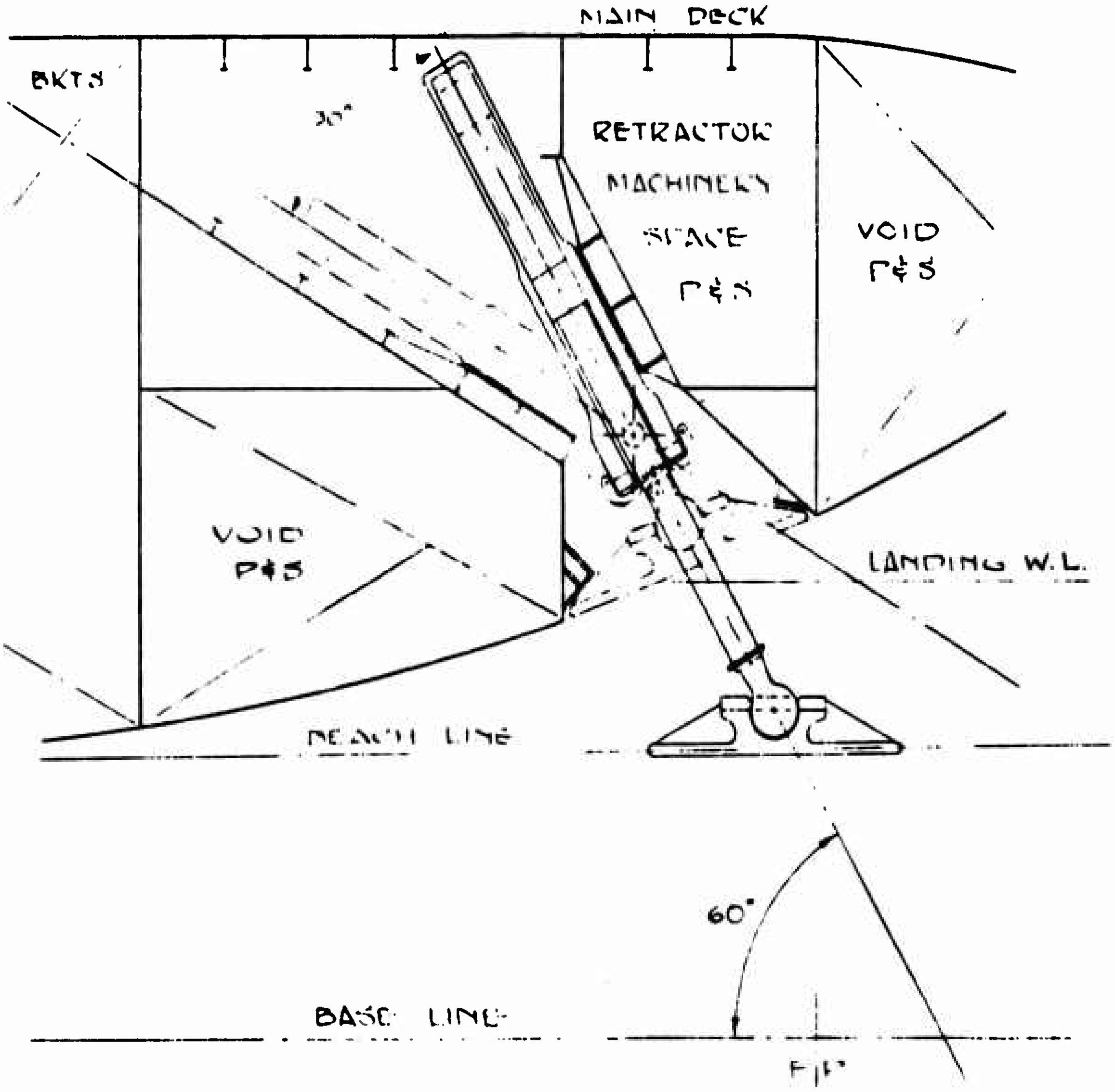
A solution for structural problems is proposed in the housing of the entire unit in a watertight sea chest inside the hull using the circular foot for the flush hull closure. A hinged connection between retractor and lower end of the cylinder has been indicated to reduce column effect. The retractor foot is connected to the ram piston with a ball and socket joint, and an alternate universal joint connection is shown.

A bearing strength of wet sand has been assumed to be 6000 lbs/sq. ft., the coefficient of friction of steel on wet sand taken as 0.70, and the shear strength of wet sand zero. With a 12" I.D. hydraulic cylinder, an oil pressure of 1548 lbs. is required to develop 80 tons. The maximum horizontal component of the retractor, at an angle of 35° from the normal to the beach slope is about 46 tons when fully loaded.

Preliminary weight figures for one retractor indicate a ram piston and foot of 6400 lbs. and ram cylinder, trunnions, etc. of 5300 lbs., a total, excluding all hull structure, of 11700 lbs. per unit.

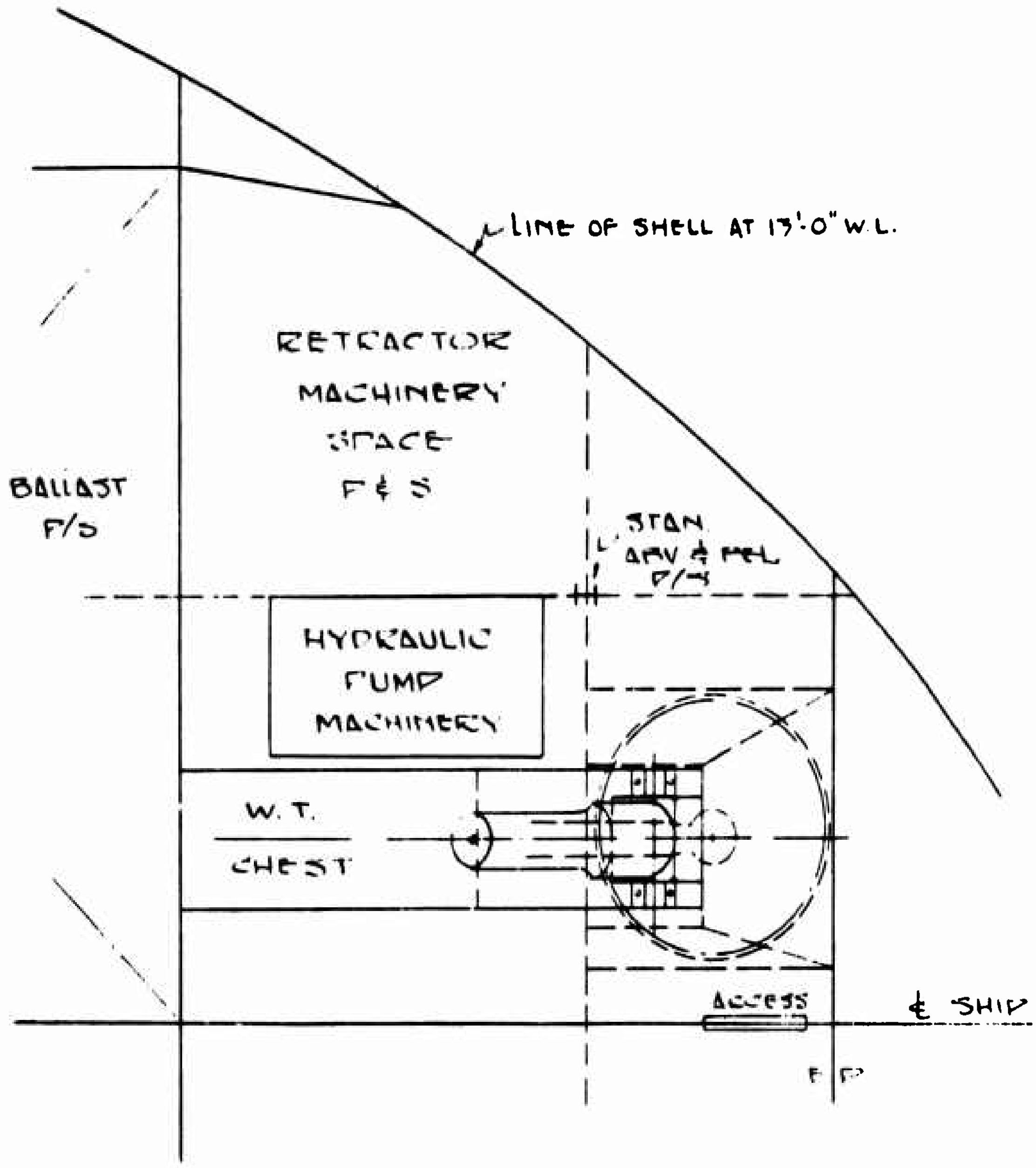
It must be emphasized that this retractor is designed to be used on a sand beach, and can only be used when the vessel moves straight off from the beach. If any slewing forces are applied to the vessel simultaneously with the jacking force, the retractors will act to resist this pivoting, and would fail in bending if the ship did pivot. In addition, it would probably be desirable to incorporate a jettisoning feature into the design of the retractor foot, if it becomes necessary to break clear should the foot become fouled for any reason.

In comparison, it should be noted that U.S. Navy LST542 class vessels had a 3,000# Danforth stern anchor to aid in retracting from the beach. The pull was supplied by a wire rope stern anchor winch which could produce a line pull of about 45 tons at a speed of 10 feet per minute.



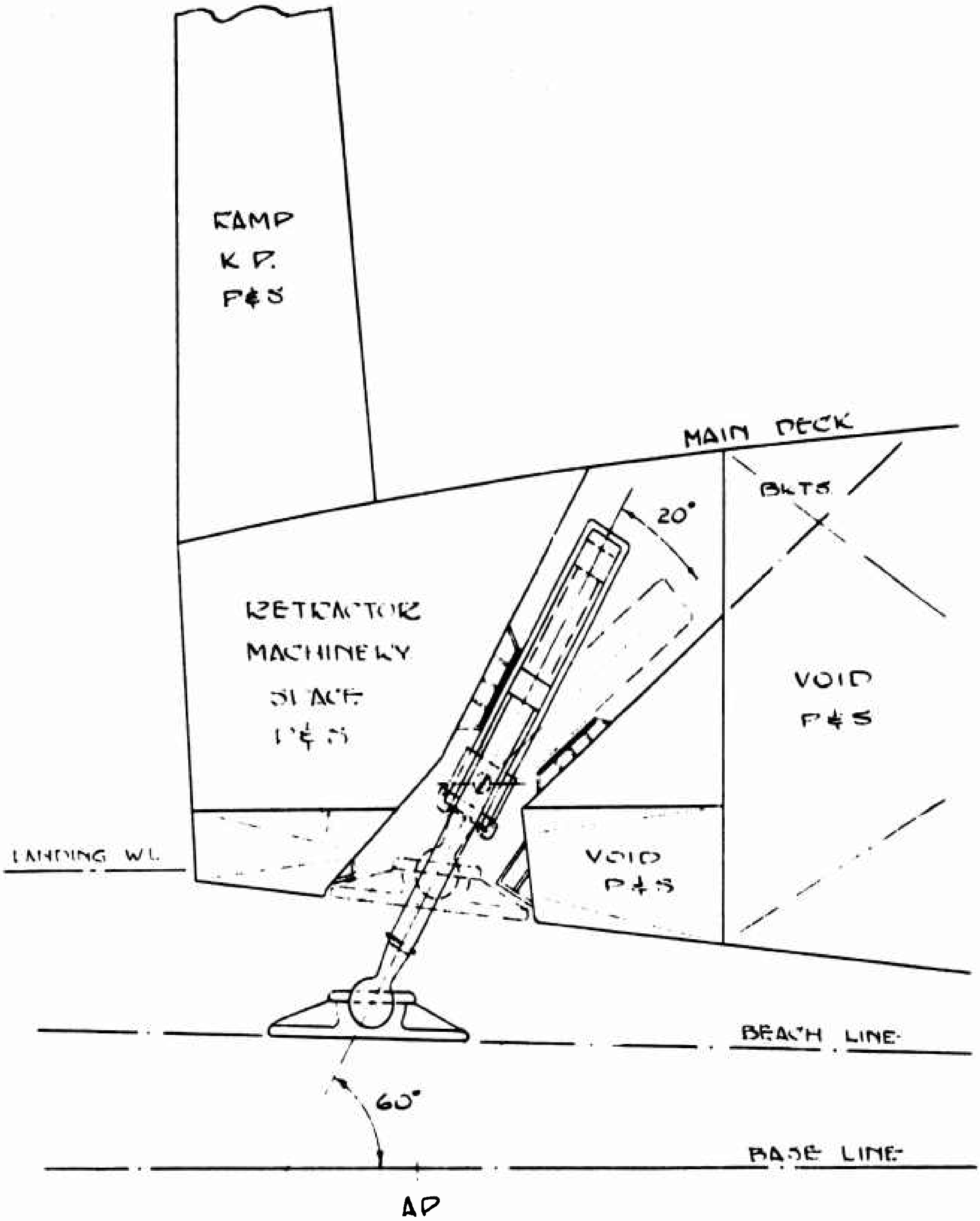
ELEVATION 4'-0" OFF ℄ P&S

80 TON HYDRAULIC BEACH RETRACTOR
FOR 300 FT. BEACH LIGHTER (BOW RAMP DESIGN)
SKETCH A



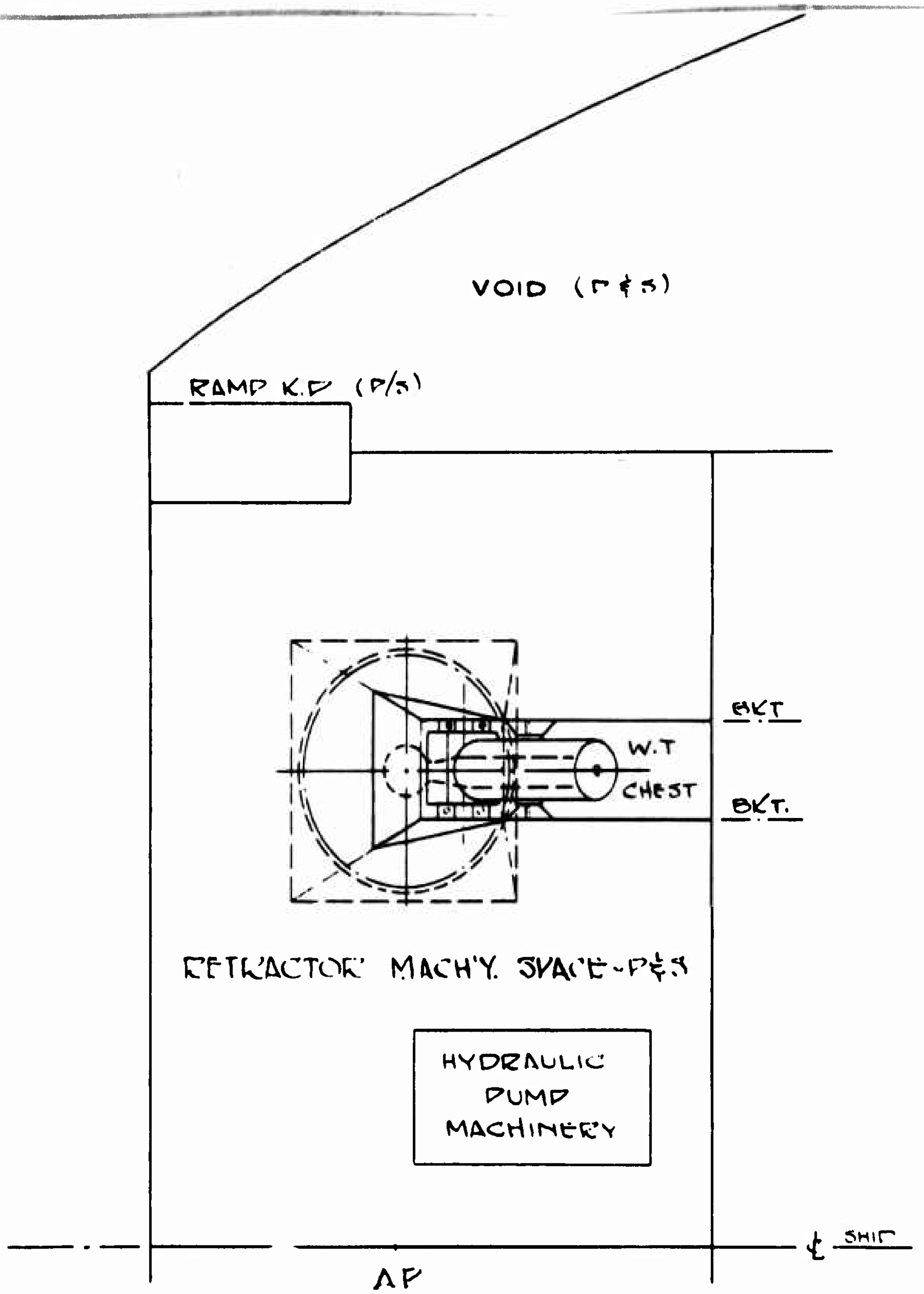
PLAN OF RETRACTOR MACHINERY SPACE

80 TON HYDRAULIC BEACH RETRACTOR
FOR 300 FT BEACH LIGHTER (BOW RAMP DESIGN)
SKETCH B



ELEVATION 12'-0" OFF ℄ (P&S)

80 TON HYDRAULIC BEACH RETRACTOR
FOR 300 FT BEACH LIGHTER (STERN RAMP DESIGN)
SKETCH C



PLAN OF RETRACTOR MACHINERY SPACE

80 TON HYDRAULIC BEACH RETRACTOR
FOR 300 FT BEACH LIGHTER (STERN RAMP DESIGN)
SKETCH D

H. DESIGN SIMPLICITY, OPERATIONAL SIMPLICITY AND INITIAL COST

1. Angular Thrust Propulsion

As developed the design will require four main propulsion units, means to control four side rudders and means to control and raise two retractable rudders.

Mechanical means of retracting might be necessary in view of the low slewing moment which could be produced in beached condition.

2. Vertical Axis Propulsion, Bow Ramp

This design requires only two main propulsion units and no steering gear.

The high side thrust and slewing moment might make mechanical retraction unnecessary and thus simplify the design.

As demonstrated on the river towboat, maneuvering control would be excellent and simple.

The only available design of a vertical axis propeller is for the 1000 HP unit built by the Pacific Car and Foundry Co. Advice from this company indicates that the engineering effort required to design a larger unit would be in the order of six months.

The present study designs have been developed using the space requirements for the 1000 HP units. Some modifications of the designs would be required for the larger units.

Although there have been several installations of vertical axis propeller units up to 2000 horsepower their general application, particularly for ocean service, has been limited.

3. Vertical Axis Propulsion, Stern Ramp

The same comments regarding the space requirements and the availability of the vertical axis units mentioned above apply to this proposal.

The retractable steering skegs add to the mechanical equipment required and detract from operational simplicity.

Vulnerability of the propellers to damage when the vessel is moving forward in shallow water is probable.

The configuration of the keel line as presently developed would add to the difficulty of construction and dry docking.

4. <u>Tunnel Stern Propulsion with Directional Propellers</u>

Two main propulsion engines, two outboard units and steering gear for two rudders would be required.

The directional propeller units would be required to be of extremely rugged construction since the units would be subjected to severe forces when beaching in a heavy sea.

5. <u>Comparative cost figures for the four design proposals are available and will be given to Tradcom.</u>

III. CONCLUSIONS - EVALUATION, RECOMMENDATIONS

1. Each of the proposals which have received consideration can be developed to satisfy the Military Characteristics as required.

2. Comparative evaluation of the four main proposals.

Angular Thrust Propulsion

Resistance	Relatively good in smooth water and waves.
Propulsive Efficiency	Relatively good in smooth water.
Resistance to Broaching	Relatively low. It is believed that this will be appreciably reduced by propellers sucking air under any but smooth water conditions.
Maneuverability	On the basis of model tests maneuverability would be poor with propeller steering only. Probably would need rudder action for directional stability.
Seaworthiness	Relatively good in terms of hull form and ramp location. Air sucking of propellers in waves will seriously reduce propeller thrust and adversely affect control and ability to maintain headway.
Simplicity	Hull form good, complicated steering.

Vertical Axis Propulsion - Bow Ramp

Resistance	Not as good as angular thrust model in smooth water and in waves.
Propulsive Efficiency	Good
Resistance to Broaching	Excellent
Maneuverability	Excellent using propeller steering only.

Seaworthiness	This will depend upon the development of the bow ramp, studies of shipping water and development of freeing ports and bulwarks. It is believed that a satisfactory solution can be developed. Further development of the lines will probably reduce the pounding forward that has been observed on the model.
Simplicity	Good except possible complication of bow ramp construction and maintenance.

<u>Vertical Axis Propulsion - Stern Ramp</u>

Resistance	Probably higher in smooth water than other proposals.
Propulsive Efficiency	Poor.
Resistance to Broaching	Relatively good.
Maneuverability	Good using propeller steering only but would probably require retractable skegs.
Seaworthiness	Relatively good but hull would probably pound in way of propellers.
Simplicity	Steering skegs add to mechanized equipment. Keel line complicates construction and dry docking. Propellers might be subject to damage when proceeding in shallow water.

<u>Tunnel Stern Propulsion - Direction Propellers</u>

Resistance	About the same as vertical axis-bow ramp design.
Propulsive Efficiency	Relatively good.

Resistance to Broaching	Not as good as vertical axis proposals.
Maneuverability	Probably good.
Seaworthiness	Same as bow ramp-vertical axis model.
Simplicity	Two propulsive systems required when beaching.

3. Evaluation of the five alternate proposals previously eliminated for further study by the Design Agent and Tradcom representatives.

Angular Thrust Propulsion, Modification A
Plan PR-1888-H7

The semi-tunnel appendages would probably increase EHP and might result in increased thrust-deduction. Propellers would break surface in heavy weather and appendages might be subjected to severe forces. For minimum resistance the appendages would require careful fairing and might be costly to build.

Angular Thrust Propulsion, Modification B
Plan PR-1888-H8

The bilge recesses would probably increase EHP with a questionable effect on propulsive efficiency. The increased beam would also probably increase EHP. The wave hollow formed by the bulge between recesses might extend aft to after propellers and increase air sucking at high speeds. A large amount of experimentation would be required to establish the tunnel shape and clearances.

Tunnel Stern Propulsion with Single Vertical Axis Propeller
Plan PR-1888-H9

This proposal is unduly complicated as to propulsion and steering machinery combining conventional parallel shafts operating in tunnels with a single vertical axis propeller for maneuvering.

Tunnel Stern Propulsion with Flanking Rudders
Plan PR-1888-H10

In combination with two main propulsion units steering gear for four rudders would be provided. The rudders would be vulnerable and probably would require additional skegs for protection. The turning forces available for maneuvering would not be as great as other proposals.

Tunnel Stern Propulsion with Kort Nozzles
Plan PR-1888-H11

Although increased thrust would be available when beaching (low speeds) this does not appear to justify the additional complication.

4. Recommendations

Determination of the order of merit of the four main proposals is greatly influenced by the manner in which the individual categories of evaluation are weighted.

The Design Agent evaluates the four main proposals in the following order of merit:

1. Vertical Axis Propulsion - Bow Ramp
2. Tunnel Stern Propulsion with Directional Propellers
3. Vertical Axis Propulsion - Stern Ramp
4. Angular Thrust Propulsion

The Design Agent believes, however, that it is not possible at this time to clearly accept or definitely reject any of these four main proposals. Rather, the Design Agent recommends further investigation, principally by model tests, to confirm or modify the above order of merit. This further investigation is recommended to include the following:

1. Angular Thrust Propulsion

   Self-propelled model in waves to evaluate effect of propellers sucking air. This is presently scheduled at Stevens E.T.T. but the use of other facilities may be required, for example Taylor Model Basin.

2. Vertical Axis Propulsion - Bow Ramp

   Further tests in waves at Stevens ETT to (a) evaluate altered lines believed less liable to slam, (b) study action of trapped water on deck and (c) measure impact forces on ramp.

3. Vertical Axis Propulsion - Stern Ramp

   Recondition available model vertical axis propellers for self-propulsion tests at Taylor Model Basin to (a) evaluate power requirement and (b) determine whether flat bottom forward in way of propellers leads to serious slamming.

THE FOLLOWING PLANS ACCOMPANY

AND FORM A PART OF THIS REPORT:

PLAN NO.		TITLE
PR-1888-H1	-	Angular Thrust Propulsion Outline of Decks and Inboard Profile
PR-1888-H23	-	Vertical Axis Propulsion - Bow Ramp Outline of Decks and Inboard Profile
PR-1888-H3	-	Vertical Axis Propulsion - Stern Ramp Outline of Decks and Inboard Profile
PR-1888-H12	-	Tunnel Stern Propulsion with Directional Propellers - Outline of Decks and Inboard Profile
PR-1888-H29	-	Angular Thrust Propulsion Midship Section
PR-1888-H16	-	Vertical Axis Propulsion - Bow Ramp Midship Section
PR-1888-H7	-	Angular Thrust Propulsion MOD. A Outline of Decks and Inboard Profile
PR-1888-H8	-	Angular Thrust Propulsion MOD. B Outline of Decks and Inboard Profile
PR-1888-H9	-	Tunnel Stern Propulsion with Vertical Axis Propeller - Outline of Decks and Inboard Profile
PR-1888-H10	-	Tunnel Stern Propulsion with Flanking Rudders Outline of Decks and Inboard Profile
PR-1888-H11	-	Tunnel Stern Propulsion with Kort Nozzles Outline of Decks and Inboard Profile

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Unclassified report

This report covers the development, design, construction, and testing of a beach discharge lighter. The
(over)

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2. Landing Craft
3. Yard Craft

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